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ABSTRACT

Designed as a basic reference document, the report has mapped the economic and technological territory of the food service industry, examined the dynamics shaping the industry today, and examined questions in need of further research. It is a volume that might be useful to food service teachers and curriculum planners as well as a volume which might be of interest to the industry and students. The report is organized into six main sections, authored by professionals in the field: (1) Industry Dynamics: An Institutional View, (2) Food Processing and Preparation Equipment As It Shapes the Future of Food Service, (3) Food Processing Methods: The State of the Art and Its Future Effect on Food Service, (4) Nutrition As It Affects and Will Affect Food Service, (5) Planning Aspects Affecting the Future of Food Service: A Study of Planning and Spatial Issues, and (6) Economic Trends Influencing the Future of the Food Service Industry. A bibliography or annotated bibliography is included at end of each main section. The concluding, partially annotated Bibliography of the Economics of Food Consumption (59 pages) has been organized to make information available to those particularly interested in hospitality industry food service. (EA)

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**THE FUTURE OF FOOD SERVICE:
A BASIS FOR PLANNING**



FOOD SERVICE AND HOUSING ADMINISTRATION

THE PENNSYLVANIA STATE UNIVERSITY

QE005008

THE FUTURE OF FOOD SERVICE:
A BASIS FOR PLANNING

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THE PENNSYLVANIA STATE UNIVERSITY
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June, 1974

Acknowledgments

Acknowledgments in a project of this scope can never be adequate, but I want to give credit where credit is due in spite of the danger of an omission. First, my thanks go to the Research Coordinating Unit Director of the Pennsylvania Department of Education's Bureau of Vocational Education, Dr. Carroll A. Curtis and his staff. And particular thanks also go to the RCU's Dr. Clarence Dittenhafer, who endured a long series of efforts to conceptualize this project. He did so with patience, offering many useful insights and a willingness to bear with some initial wrong turns. Without the added encouragement and support of Miss Caroline Kratz, Senior Program Specialist in Home Economics at the Pennsylvania Department of Education, and her staff, this effort would almost certainly have been impossible.

John Swinton, who provided the project with editorial assistance, managed to bring this volume together without friction within time constraints that would have made weaker men cringe. His is the major merit for clarity in presentation; given the difficulty of the subject matter, he cannot be blamed if some of us seem a bit plodding. His voice shaped the concept of the project and its continuation, just as his hand shaped this final product.

Encouragement, too, came from the food service professionals who agreed to help with this project: Dick Benefield, President of the Pennsylvania Hotel and Motor Inn Association; William Lapitsky also of the Association; Ms. Jane Armstrong, Vice President for Consumer

Affairs of the Jewell Tea Company; and Ms. Josephine Martin of the Georgia State Department of Education, School Food Service. The time frame within which we worked did not permit us to make as full a use of these distinguished professionals as we had planned; but they offered their encouragement, and they continue to offer their knowledge. Ms. Hester Munden, Home Economics Consultant of the Pennsylvania Department of Education served with this group, suffered through an early presentation of some of the material in this study, offered encouragement, and agreed to serve as a consultant to the project in the future. We owe her a special note of thanks.

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Nancy Goerisch, who worked closely with me on the project, deserves particular mention. Not only did she do much of the detailed research, but she also directed others in their research and suffered much of the administrative trivia related to carrying out the project.

Long, hard, constant, and often tense work was accomplished by a veritable corps of secretaries: Janet Villastrigo, Grace Collins, Bonnie Williams, and Ruth Kilhofer, the last of whom not only typed many drafts and final mats, but also produced many of the charts and appendices that appear herein. Rhoda Williams, who commanded this corps, endured all the special troubles that accompany responsibility

with grace and patience, keeping everything else her office does running smoothly at the same time.

Finally, a personal word to our readers: Critical reactions to this volume will be most helpful to future research. I hope a realization of the time pressure under which this study was completed--seven months is not a long time even for such a modest effort as this--will bolster your patience. Because our purpose was to bring the tools of several disciplines to bear on the world of food service, you will probably find some unavoidable duplication. Nevertheless, I believe that this study offers some useful planning approaches and future considerations for food service workers, and I hope you agree.

Thomas F. Powers

June 28, 1974

University Park, Pennsylvania

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INTRODUCTION

Thomas F. Powers

In early 1972 the Food Service and Housing Administration (FSHA) Faculty at Penn State adopted a basic research aim: to identify the major forces shaping the food service industry with a view to understanding the probable direction of change in those industries. This is an interesting question, worthy of study in itself. The issues addressed are of vital importance to the food service industry. Most fundamentally, however, the need to study this issue results from the needs of curriculum planners at all levels of Food Service Education.

Recognizing the highly traditional structure of post secondary Hospitality Education, the Research Coordinating Unit (RCU) of the Pennsylvania Department of Education provided funds in 1971 for the redevelopment of Penn State's associate degree in Hotel and Food Service Management. Because of RCU's interest in Hospitality Education, FSHA approached that agency about a base line study to develop a picture of the Food Service industry of 1985-90 to provide necessary information for planning Vocational Technical food service curricula at the secondary level. With the support of the Home Economics staff of the Department of Education, RCU offered encouragement to our efforts.

Over the next year, a team of research scholars from across the University interested in this area were identified from the areas of food science, engineering, nutrition, economics, urban systems planning, as well as that of Food Service and Housing Administration. In late

1973, funding became available for a literature search and planning study and work began in December of that year. The present volume is one outcome of that study.

A second outcome of our work is the design for a second phase which will be implemented beginning July 1, 1974, to construct "scenarios" of the future world of food service--realistic explorations of the effects of reasonably foreseeable changes.*

In this second phase of the study, a base will be provided for considering issues such as what kind of food service industry is likely by 1985? What kinds of jobs will such an industry offer? What knowledge and skills will those jobs require? Which parts of the knowledge and skill base can best be addressed by education? Ultimately, then, our product should not be a curriculum made up of the traditional "pieces" of food service education but a reasoned basis for planning vocational technical curricula of the future. The real clientele of the study--freshmen entering high school in 1976 (and thereafter)--will not have reached their 25th year by 1985 and will still be trusty "under 30's" by 1990.

The present work is not basically about the future; it is a study of the present (which will serve, however, as the basis of the subsequent effort to consider the future). The purpose of the study is to map the economic and technological territory of the industry; to identify the dynamics shaping the industry today; and, to separate out from the many useful questions researchers might find of interest those which are

* For a discussion of the use of "scenarios" in considering the future and a useful, popular exposition of some of the problems and pitfalls of long range forecasting, see Kahn and Weiner's The Year 2000.

crucial to an orderly consideration of the future.

Food Science and Engineering.

As Professor Joseph MacNeil makes clear in the section on food science and technology, the potential for change within the existing technology is enormous. A picture emerges of a technology that is past basic, ground breaking research and moving at an accelerating pace into highly specialized applications. Specialized, high volume systems directed at a particular (food) raw material or group of food products are coming into their own, increasing the volume of individual products available, thus reducing costs through economies of scale. Difficulties of processing particular products are being overcome and increasingly the final product is a combination of products which, themselves, are already highly processed by the time they reach the final processing steps.

A principal research interest of Professor Frank Schmidt is heat transfer, a subject which includes topics such as cooking, freezing and cooking viewed from an engineering standpoint. While significant advances appear to be at the point of adoption or in the offing in the use of radaranges and heat pipes, no basic technological breakthroughs are expected in heat transfer technology. Interestingly, the major change he sees in equipment does not represent so much a technological change as a systemic change resulting from equipment systems with a capacity enormously greater than even a large kitchen and offering substantial labor economies. These new systems, however, are able to operate economically at much lower levels of output capacity than the typical frozen food manufacturing plant, thus offering substantially

greater flexibility in the line of frozen (or chilled) prepared products available.

As Schmidt points out, the communication problems between scientists, engineers, equipment manufacturers, and food service managers retard the work of all. Development of a common vocabulary, a recognition of the valid point of view of the others within this group, and an understanding of their problems would be highly desirable. One likely side effect of the present work is the development of concrete efforts at this University to encourage such intercommunication.

A significant point which emerges from a consideration of the sections on Food Science and Engineering, which is confirmed by field observation, is that any product or process innovation that benefits the independent also benefits the larger institutional operation. Many of the most recent developments in equipment do offer unique advantages to large-scale food service operations--and operations that learn to use large-scale food production in commissaries and other mass feeding contexts. A visit by project staff to the National Restaurant Exposition revealed a number of new, large-scale food production systems, but only one new piece of equipment which was usable by the individual restaurant (a steam convection cooker).

Since consumers' views of restaurant prices are shaped by the price of alternate services, the availability of economies of scale in large-scale food production facilities, and the consequent ability of such operations to pass on savings to the guest, may well lead the guest to make unfavorable price comparisons when dining in restaurants unable to achieve such economies. One way in which some economies are being achieved in chain restaurants is through commissaries. The time may

have come when food wholesalers offer the "commissary function" in a broad and varied prepared product line, individualized to local tastes. The "Neff" system discussed by Schmidt certainly appears to offer advantages to those who can use such large-scale food production systems as commissaries.

Nutrition and Food Service

Professor Barbara Shannon's study of Nutrition as a factor affecting food service is especially timely. The effects of consumerism can be seen in many industries, but that force has not yet begun to affect the food service field seriously. As an industry, we still have time to act without pressure but nutrition will certainly affect the industry's future, particularly in such a rapidly growing area of public sector feeding as school lunch and congregate feeding for the aging.

Professor Shannon's study reveals important, but currently neglected areas for research. The effect of the food service establishment's production system (reconstitution and holding of product) on nutritional values has not been adequately studied nor has there been definite work on nutrition retention in frozen prepared food. Since institutional feeding is increasing rapidly and the use of frozen prepared food is accelerating in all food service settings, a clear understanding of the nutritional issues related to the two interacting areas of concern is called for. Consumerists, once aroused by an irresponsible (even if unintentional) rendering of services, generate pressures that are difficult and expensive to deal with. We may hope that the research necessary to identify the relevant issues will be

forthcoming. It seems likely that an essential part of the food service worker's knowledge base in a future, increasing consumerist world will include an understanding of the handling of products for maximum nutrition retention, particularly in mass feeding where 30 percent or more of the guest's nutritional intake is controlled by the establishment.

Urban Systems

Professor Eugene Bazan explores the effects of demography and migration on the demand for food service, pointing to the importance of increasing suburbanization. He reviews the effect of life style and income changes on the restaurant industry economic structure and the industry's response particularly franchising, in meeting this demand. These concerns are viewed in a context of changing transportation which, in turn, affects not only demand but the physical distribution systems which serve the food service industry. While the techniques Professor Bazan employs in his essay are already well-known to social scientists, they have not been widely applied in the area of food service. The implications of Dr. Bazan's contributions are, therefore, particularly interesting.

Economics and the Food Service Industry

Professor James Smith offers us a "map" of the food and beverage production and consumption system, tracing product from raw material to retail sale, showing the various sectors of food service as part of the retail establishment serving the guest.

This study shows, too, developments over time in the amount of value added by labor in the various segments of the system, and it reviews the Bureau of Labor Statistics Employment Model (which may, in

part, serve as a basis for the continuation of the present work). In reviewing the material on value added, it is interesting to note the growth in four years in the amount of labor added in food service establishments of from just under 20 percent to approximately 24 percent--an increase in proportion which is, itself, 20 percent. Statistics presented by Smith offer, in addition, support for the notion (which MacNeil has developed from another point of view) that the amount of value added to the product in manufacturing finally purchased by the retail sector for subsequent resale to the consumer has increased significantly.

Smith's summary of the patterns of food consumption of families of different sizes and different incomes offer encouragement to the food service industry. Smaller families spent nearly as much on food away from home as larger families, and there is a substantial increase in food consumption away from home as income increases. In a time of increasing incomes and smaller families, this empirical evidence of consumer behavior suggests strong continued demand for the output of the food service industry. An important point that emerges from the statistics on the industry as a whole is the very rapid growth of the institutional market.

Industry Dynamics

In the section of this report on industry dynamics, a principal focus of concern is on labor cost and supply and on the productivity of labor. Finally, a bibliographic essay sketches the dynamics of the industry as they are perceived today, principally (though not exclusively) by writers and publications outside the food service field.

Naive observation suggests that the average age of waiters and waitresses (servers) is increasing in fine dining establishments. The possibility that the number of young persons who have chosen or will choose a career as servers will be inadequate to meet the replacement needs of the restaurant industry led us to undertake a pilot study of probable labor supply trends with respect to servers. The time available was not sufficient to complete the analysis of this data by the publication date of this report. This "server study" will, therefore, be reported in a special addendum to this report.

Function of this Volume

In preparing this report, we have attempted not only to "tell what we learned" but to develop a basic document which might be useful to food service teachers and curriculum planners as well as a volume which might be of interest to the industry and to students. The detailed Table of Contents enables the reader to find those sections which cover his or her special interest. Considerable effort has been devoted, too, to indicating sources so that the reader interested in reviewing the topic further can go to the original article or articles for more detailed study. No pretence is made that this volume is a thriller; we hope it can be a useful reference document.

The contributors to this volume have used several recognized scholarly methods for collecting and citing existing information. We intentionally encouraged them to use the method both comfortable to them and useful for a reader interested in consulting original sources. In fact, one of the principal goals of this study was to acquaint a reader with the mountains of helpful literature that exist and to direct

him, quickly and easily, to that material.

Therefore we offer this suggestion: If you intend to read this volume from cover to cover, from beginning to end, by all means proceed that way. If however, having consulted the Table of Contents, you find an essay that sounds particularly interesting, turn first to the bibliography that concludes that essay. If you are a food service educator, you will probably notice titles that sound as though they could complement a lecture, a classroom assignment, or even your own research. If you are a food service professional, you may find articles that can expedite your work--that is, save you time, effort, or expense.

Having scanned the bibliography with care, next read the essay it helped shape. You will immediately see how the contributor has woven the main points of his source material into his essay. Like all bibliographical essays, these place the main points of the source materials into an overview context, narrative and sequential in tone. But in addition, they usually suggest in only a general way the more thorough treatment the subject matter received in its original context. The bibliographical essay imparts a good deal of general information; the source material that builds it typically treats specific material in far more detail.

I

INDUSTRY DYNAMICS:
AN INSTITUTIONAL VIEW

by

Thomas F. Powers, Ph.D.

INDUSTRY DYNAMICS:
AN INSTITUTIONAL VIEW

Labor Cost, Labor Supply and The Food Service Industry

Introduction

Labor is identified by economists as one of the three basic factors of production: land, labor and capital. It is clearly one of the most basic inputs to any kind of enterprise.* Labor costs of the food service and housing industries have undergone seemingly radical change in recent years and structural developments in the labor market suggest that the pattern of change will not only continue but accelerate. A number of factors have bid up the price of labor in recent years. Principal among these are a growing economy coupled with a relatively tight labor market; and, the social welfare policy of the state and national governments.

This section will review briefly historical trends in wage rates and in the minimum wage, examine new factors whose effect is only beginning to be felt from the social policy domain, and attempt to consider the probable impact of logical future developments on the work force and hence on food service and housing enterprises.

The Minimum Wage

Toward the end of the Great Depression of the 30's, the Fair

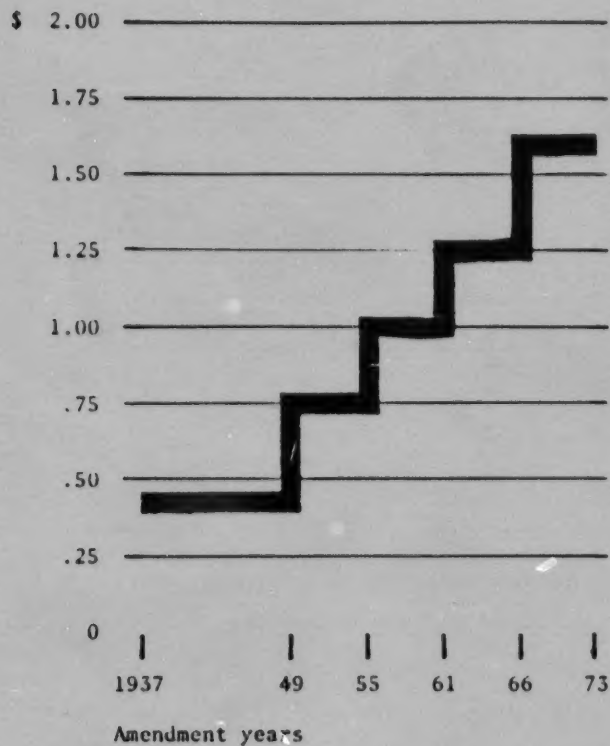
* This discussion has been adapted from one that appeared in The Cornell Hotel and Restaurant Administration Quarterly (May, 1975), pp. 5-13.

Labor Standards Act of 1938 was enacted. "The Goals of wage regulation were: 1) elimination of poverty resulting from substandard wages; 2) creation of the necessary purchasing power to maintain high levels of employment and output; and 3) establishment of a floor under wages to prevent repetition of the downward wage spiral experienced during the depression."¹ The minimum wage established by that act was 40¢ an hour. After World War II the act was amended in 1949 raising the minimum wage to 75¢ an hour. Overtime penalty pay provisions were clarified and spelled out in considerable detail in this set of amendments. In 1955 the minimum wage was raised to \$1.00 an hour and in 1961 the basic minimum wage was raised to \$1.25.

The general trend, which is summarized in Figure 1, was clearly one of raising wages. During the same time, legislation was passed broadening the coverage to include more industries and to include smaller firms. These tendencies reached the hospitality industries in 1966, when the national minimum wage was raised to \$1.60 an hour and food service and housing establishments were brought under FLSA regulation at \$1.00 an hour with fifteen-cent raises each year to bring the industry's wage to the national level of \$1.60 an hour by 1971.

The Rise in Earnings. As Figure 2 suggests, average hourly earnings have risen for hospitality industries, as have hourly earnings of other service employees and other retail employees and, indeed, as have wages for all employees. While the lines representing wages in these various groups are not perfectly parallel, an examination of the figures suggests that the rates of increase

Figure 1
Increases of Minimum Wage 1938 to 1973

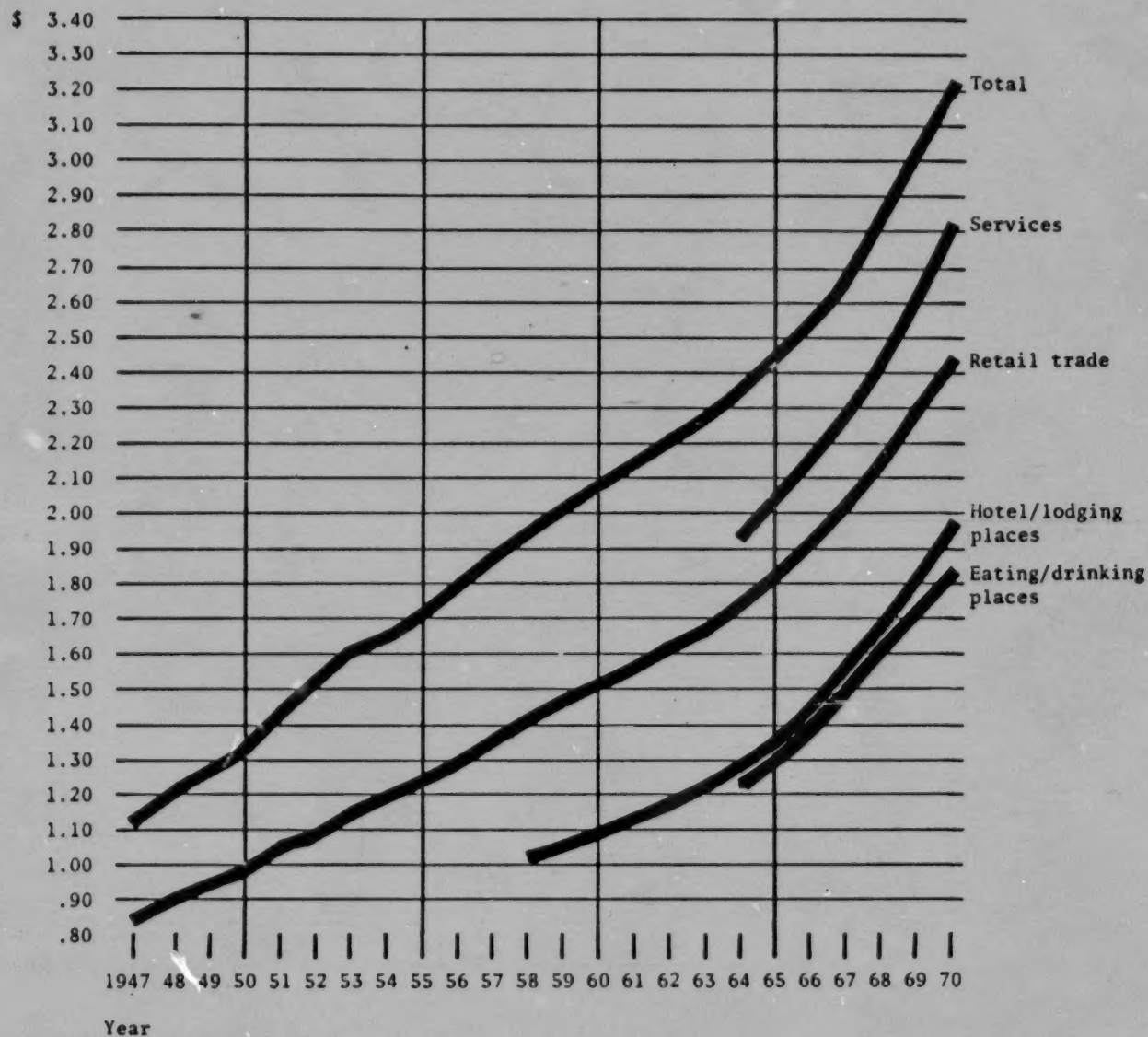


Source

Legislative Analysis: Proposed Minimum Wage Amendments, American Enterprise Institute for Public Policy Research (Wash., D.C.), Legislative Analysis #5, 93rd Congress, May 9, 1973.

Figure 2

Average Hourly Earnings of Production (Nonsupervisory) Workers
on Nonagricultural Payrolls 1947 to 1970



Source

Employment and Earnings for the United States
(1909-1971), Bureau of Labor Statistics,
pp. 548 and 565.

experienced by our industries have not been radically different than those of other industries.

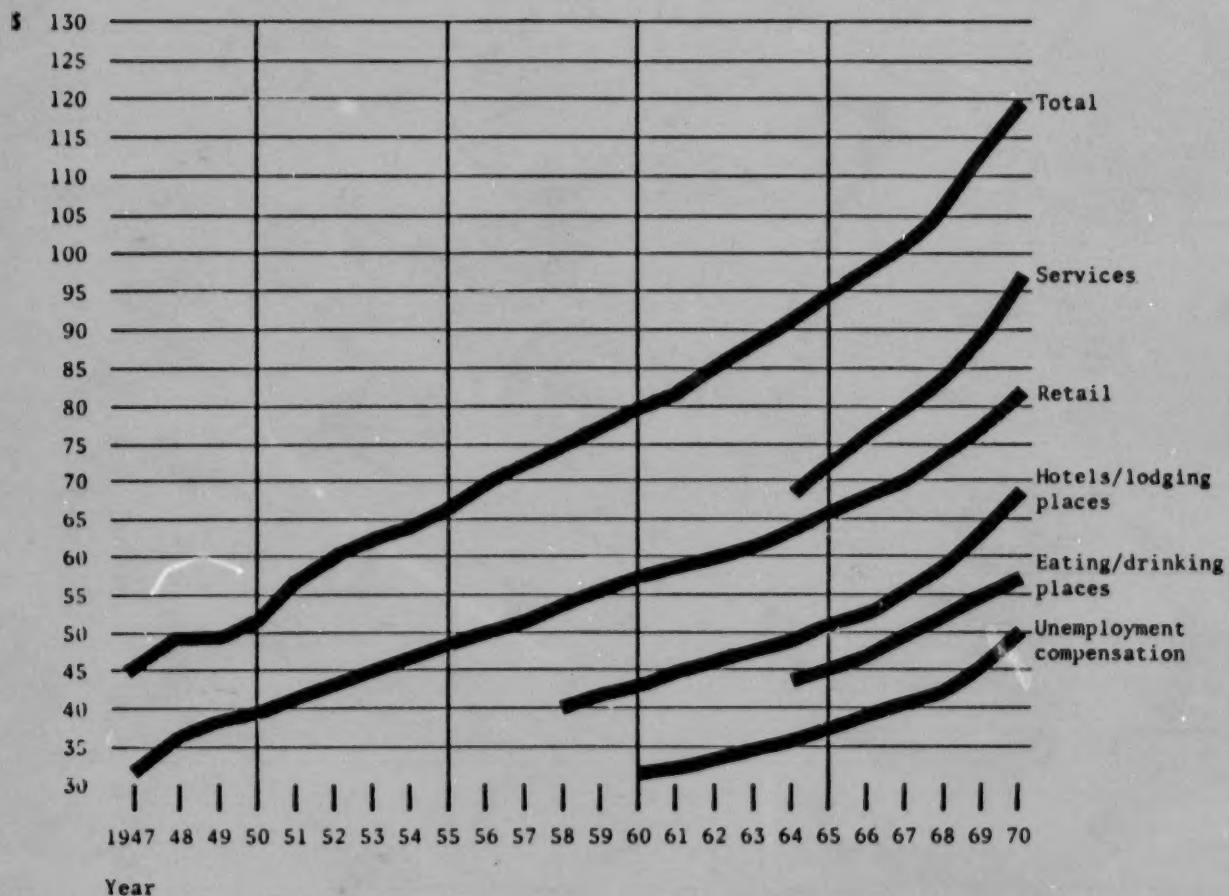
Figure 3, which reflects not only hourly income but also the length (i.e.g, number of hours) of the work week, suggests that hotel and food service employees' weekly earnings have risen at a rate similar to other employee groups. An interesting development shown in Figure 4 is that unemployment benefits (for all employees) begin to approach the rate of compensation for employees in the food service and housing industries.²

Although wages have risen rapidly in our industries, that increase has, in fact, been less rapid than the rise of wages in the economy in general. Hotel wages rose 70 percent from 1958 to 1970, while wages for the whole economy rose 80 percent. Food service wages rose 30 percent from 1964 (the earliest year for which this data is available) to 1970. In the same period, wages for all employees rose 43 percent. On the other hand, the rise in wages in the economy as a whole was accompanied by an increase in productivity. Output per man hour in the United States rose 12 percent from 1964 to 1970 and 35 percent from 1958 to 1970. Unit labor costs for the entire economy rose 27 percent from 1964 to 1970, and 34 percent from 1958 to 1970. The relationship between output per man hour, unit labor costs, and compensation in the total economy is compared with wage data for hospitality industries in Figure 4.

The Plateau in Productivity. Although no separate productivity index is available for food service and housing industries, it is important to notice that the majority of the workers in our industries

Figure 3

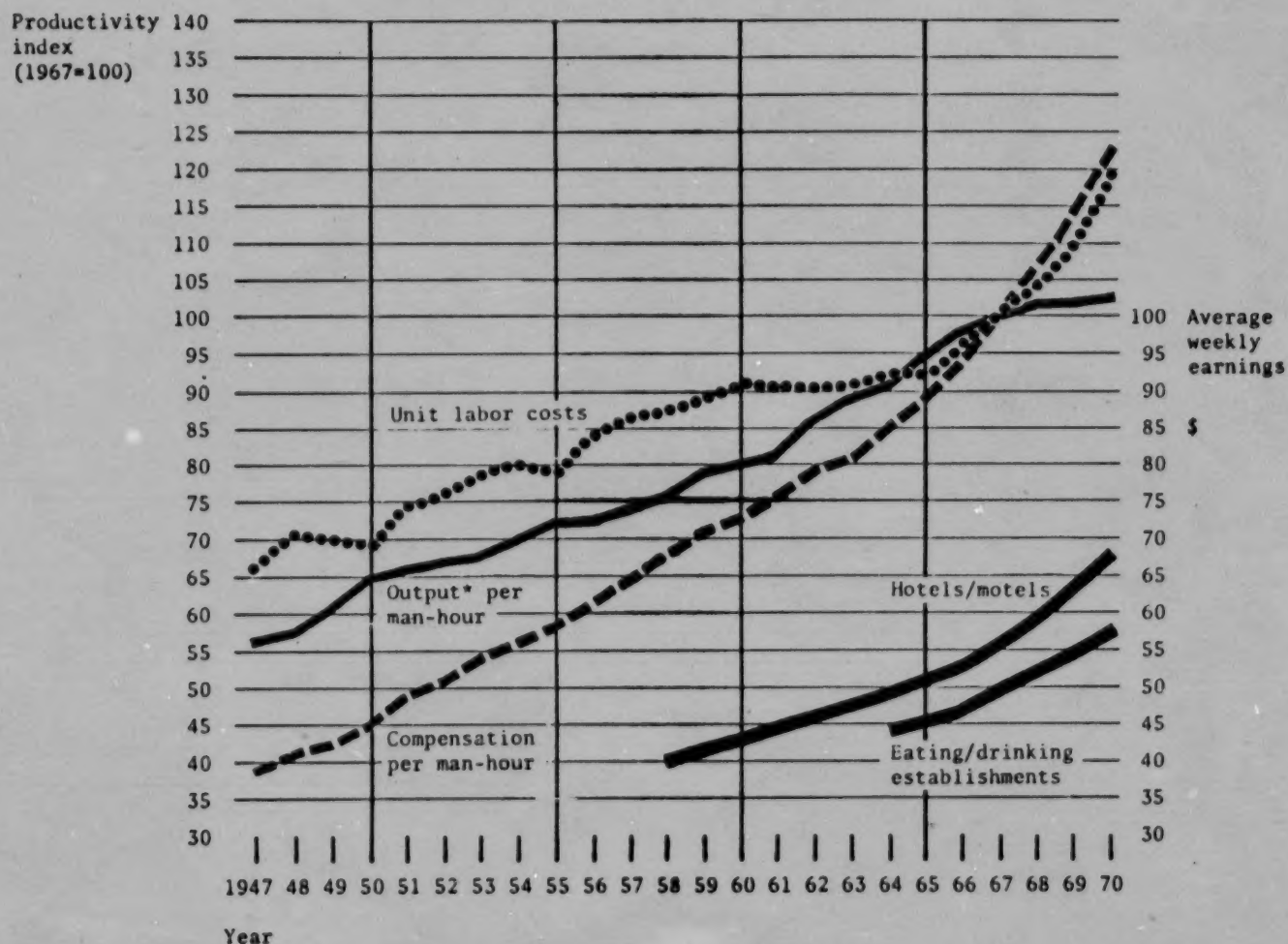
Average Weekly Earnings of Production (Nonsupervisory) Workers
on Private Nonagricultural Payrolls 1947 to 1970



Source

Employment and Earnings for the United States
(1909-1971), Bureau of Labor Statistics,
pp. 548 and 565.

Figure 4
Average Weekly Earnings of Food/Drink Establishments
and Hotels/Motels Compared to Indices of Economic
Productivity 1947 to 1970



*Output refers to GNP in 1958 dollars

Sources

Productivity indices

Economic Report of the President, 1973; Annual Report of the Council of Economic Advisors, Table C-32, "Output per Man-hour and Related Data, Private Economy, 1947-72" (p. 230).

Average weekly earnings

Employment and Earnings for the United States (1909-1971), Bureau of Labor Statistics, pp. 548 and 565.

are engaged in either personal service work or in manual occupations in which only limited productivity increases are available through mechanization. While wages for hospitality industries rose at a slightly slower pace than in the economy as a whole, it seems reasonable to assume that productivity in traditional hospitality firms such as hotels and restaurants rose only marginally.

Some increases in productivity might be noted, for instance in the trend toward more self service (for instance in the use of buffets, reduction in bell staff services) and limited economies may have been realized from such automated devices as dial switchboards. The basic picture, however, remains one of a labor intensive, personal service industry. If this reasoning is correct, it follows that unit labor costs (i.e., the portion of revenue from each cover sold or room rented required to cover labor costs) in the hospitality industries have risen at a substantially higher rate than they have in the economy as a whole.

It is instructive to look at the firms in our industries which have improved productivity. In fast food, where the number of covers served per employee is surely radically higher than in the more traditional restaurant setting, what we have is not so much the introduction of automated equipment as the complete redesign of the food service system relying on a drastically simplified menu and self-service,³ as well as the introduction of industrial engineering techniques accompanied by a certain amount of automation.⁴

As wages rise (along with other costs) the operator has really only two choices, aside from going out of business. Those are either

to rework the system to eliminate labor (as in fast food, perhaps, by drastically simplifying the system) or to incorporate the ever higher cost stricture in the price offered to the consumer and maintain the traditional level of service. As prices in traditional service settings rise, that increased price structure offers an inducement to innovators to develop new, simplified formats, such as the fast food operations have done, to compete on a price basis with the traditional establishment.

Social Policy and Labor Supply

Writing in 1965 on the labor market of the lodging industries, John P. Henderson stated:

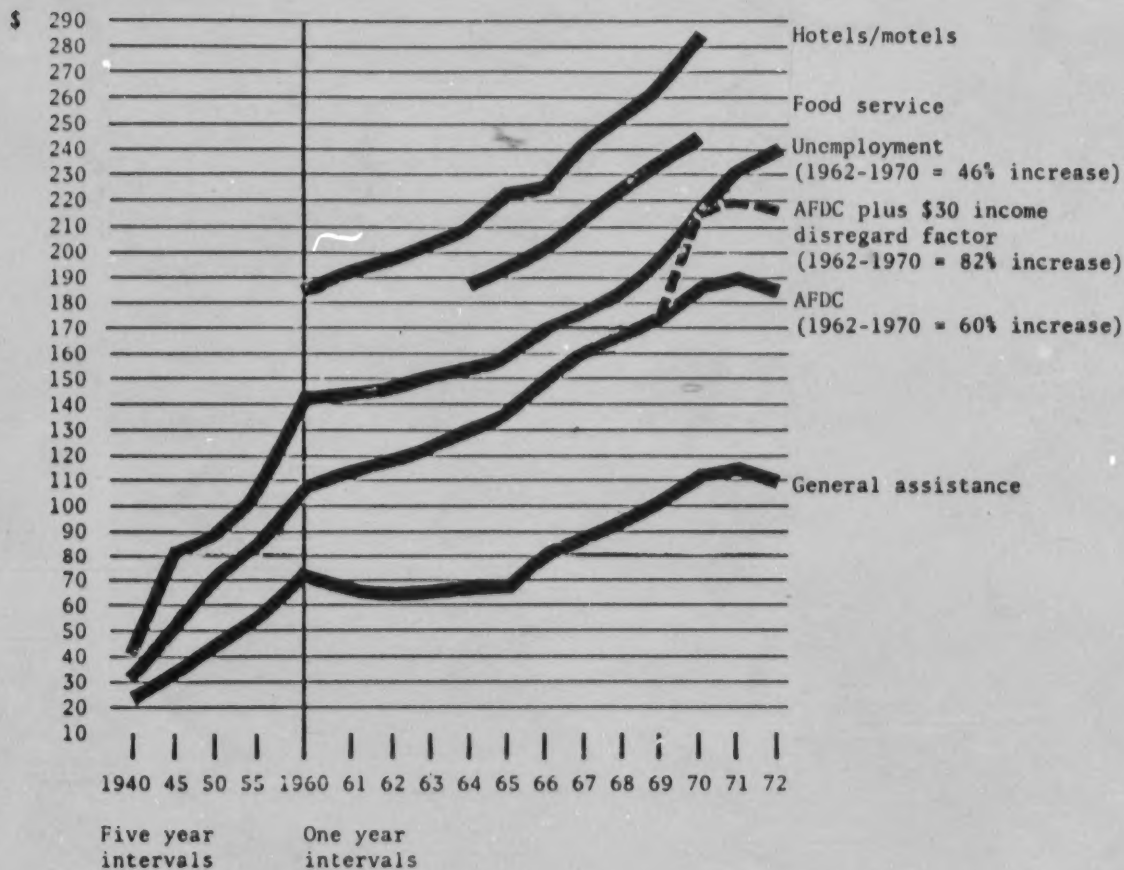
But for the unskilled 50 to 60 percent of workers at the base of the lodging industry pyramid, there are few alternatives, and these workers do not have much opportunity to move into new occupations and industries. It is this lack of mobility that has allowed the industry to continue to pay such low wages to many employees, since it is obvious there has been no need to offer higher wages to attract the requisite number of workers.⁵

This condition, so recently described by Professor Henderson, may, in fact, be changing radically at the present time. Figure 5 compares wages in the food service and housing industry to incomes available for "non work." While general assistance has never been competitive with wage earnings, patterns set by AFDC (Aid for Dependent Children) are clearly on the verge of being competitive with the wage scale of our industry.

Work vs. Welfare. In evaluating Figure 5 it is important to realize that the hotel or restaurant worker of interest is not the tipped worker but the 50 to 60 percent Henderson referred to as

Figure 5

Average Monthly Benefits: AFDC, General Assistance and
Unemployment* Compared to Average Monthly Wages*
for Food Service and Hotel/Motel Establishments



Notes

*Wages and unemployment data represented by weekly amount x (4.3)

General assistance and AFDC benefits per family

Wages and unemployment per individual

Welfare benefits measure cash benefits only--does not include other services such as counselling, medical services, food stamps and non-recurring grants such as special allowances for winter clothing or furniture

Sources

Food service and hotel/motel establishments
Employment and Earnings for the United States (1909-1971), Bureau of Labor Statistics, pp. 548 and 565.

AFDC, general assistance and unemployment benefits
Current Operating Statistics in the Social Security Bulletin, Dec. 1972

unskilled. Thus, understatement of tipped income is not a factor in the comparison. On the other hand, it is perhaps even more important to notice that the welfare benefits shown in Figure 5 are probably a significant understatement of the actual benefits available. In addition to the dollar income received from AFDC, generally included

Table 1

Changes in Average Minimum Wage and
Non-Wage Incomes in New York State

1962-67	Increase
Average Wage.....	13%
Minimum Wage.....	30%
Welfare Allowance*.....	40%

*Average of all welfare programs

Source: Durbin, Welfare Income and Employment

Table 2

Changes in AFDC Payments, Benefits and
Recipients in New York State

1965-70	Increase
AFDC Expenditures.....	156%
Increased Benefits.....	52%
Increased Number of Recipients.....	48%

Source: Durbin, Welfare Income and Employment.

in those benefits are free medical care, food stamps (and free lunch for school children), and substantial free counseling services on economic, family, and social matters. As one authority has put it, "it is worth pointing out here that a job at the minimum wage level in New York City yields an equivalent annual income significantly lower than the scheduled welfare budget allowance for a family of four."⁶

Welfare benefits, as Figure 5 indicates, have increased

dramatically in the past thirty years. Durbin, in a study of welfare benefits in New York states that "welfare benefits increased more than average wages in manufacturing, more than the minimum wage and more than the average or maximum unemployment compensation benefits."⁷ Between 1962 and 1967 Durbin's study shows average wages rose 13 percent while the minimum wage rose 30 percent and the welfare allowance rose 40 percent. AFDC expenditures have grown 156 percent between 1965 and 1970. This growth was attributed to increased benefits (52 percent) and increased number of recipients (48 percent). These rates of change are summarized in Tables 1 and 2.

Another point to recall in gauging the understatement of the welfare benefit is suggested by the dotted line in Figure 5 which begins in 1969 for AFDC, referred to as the "income disregard factor." Beginning in that year the first \$30 of earned income (and a declining portion of all income over that amount) was disregarded in computing welfare benefits. While the intent of this is to encourage employment on the part of individuals on welfare, it may have the additional effect of making welfare more attractive, since a person can work about one day a week in some kind of part-time job without any welfare reduction. Moreover, case workers commonly ignore sporadic, non-recurring earned income, and many welfare recipients engage in baby sitting and a wide variety of other activities that are convenient for their status in life and which are difficult for welfare departments to establish as bonified employment for purposes of reducing welfare payments.

The most generous benefits for non-work are found in AFDC, and

AFDC is certainly the fastest growing form of welfare. These benefits are generally (though not exclusively) supplied to female heads of household. Thus it might be thought that the effect of this policy is to reduce the number of women in the work force. In practice, however, welfare benefits have the effect of reducing work force participation by adult male and teenage children.⁸

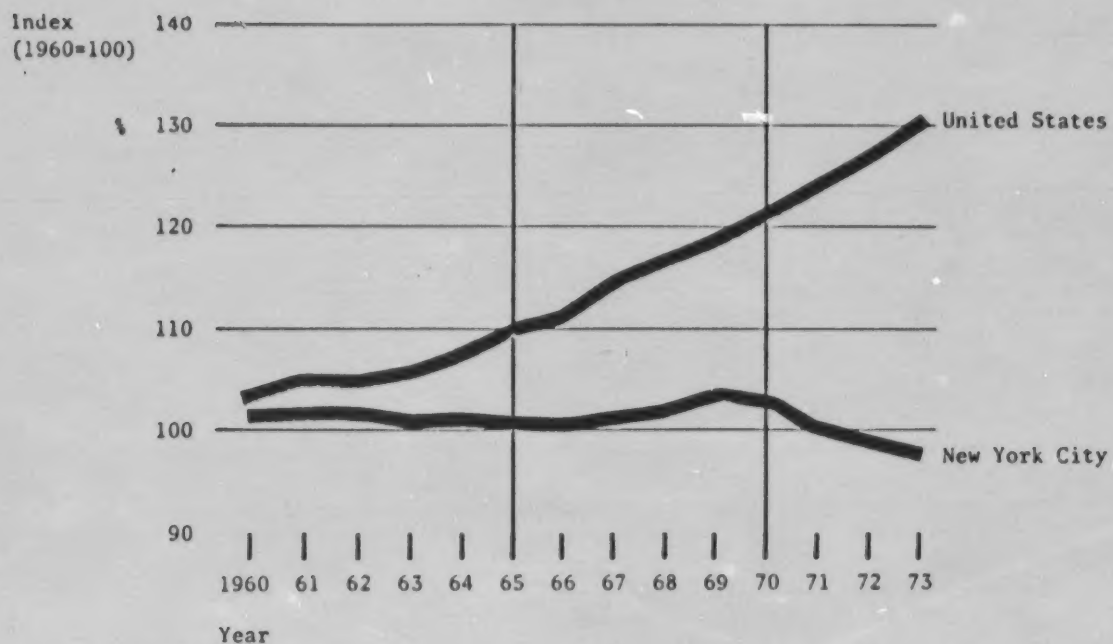
A recent study by the Economics Department of the First National City Bank of New York discussed changes in work force size in New York City. Figure 6 shows a comparison of work force trends in New York City with national trends. The reduction in New York's force is accounted for by two factors, a stable level of population and a decline in labor force participation contrasted with a rising national participation rate. The logical speculation which arises out of this bank's study is that the reduction in work force participation is in large part due to welfare alternatives. The reduction in the work force is "centered in, although not limited to, the younger segment of minority, female workers."⁹ This, quite obviously, is also a reasonable description of much of the clientele of AFDC.

Where Are We?

At this point, it is clear that for many years our industries have been subject to the pressure of rising wage rates. As wage cost has increased, either productivity was increased to offset some or all of that cost by redesigning the system, using ever simpler food service systems as in fast food, or the price structure of the

Figure 6

Work Force Size: New York City Compared to United States



Note

The U.S. index refers to the civilian labor force as reported by households in the Current Population Survey. The New York City index refers to the work force based on reports by business establishments to New York State Labor Dept. and on unemployment compensation data.

Source

Economics Department, First National City Bank

establishment was changed to pass on to the consumer the increase in the cost of the factors of production.

The rising price of the products and services of the traditional hotel and restaurant industries has provided an inducement to innovators to design still more systems which were of lower cost to operate and hence could be provided to the consumer under the umbrella of the price structure of traditional establishments.

A developing trend, however, in social policy is the growth of various welfare incomes to the point where they generally approach and commonly exceed the incomes of those working at the lower end of the wage scale. It should be noted that these benefits do not apply to all workers, nor do they apply all the time. As a general rule, AFDC benefits are limited to women who are heads of households, while unemployment is available only for a period of time (an average of 26 weeks) following on some employment and thus cannot be pursued as a way of life permanently. On the other hand, the rising level of the general welfare benefit, more generous standards in the granting of food stamp benefits, and the constant pressure to raise the floor of general assistance suggest that the standards now set by AFDC may emerge as the set of standards to be applied to a broader group of welfare recipients within the foreseeable future.

At least two effects can be anticipated from an increasingly generous welfare policy. One of these is to establish an income floor for all workers that may be more significant than the minimum wage. Clearly, if an employee can make more money by not working than by working, the employee is likely to engage in a rational choice based on economic considerations and choose the more remunerative

"non-work" over work. Moreover, many observers of the food service and housing industries have noted that there is little in the way of intrinsic reward to be had from our industry's unskilled jobs. As Durbin has pointed out, "if working had positive value in addition to the goods and services purchaseable, the person would not have to be paid so much to give up his leisure; but, obviously, if work is actually so distasteful that it has a negative value, even more has to be paid."¹⁰

A second probable impact is that today's welfare benefits offer a choice between work and non-work to ever larger number of employees. Thus, a person who shrinks from the stigma of being a welfare recipient may nevertheless choose that role. If she is a mother for instance, she may think that stigma less important than her desire and need to be with her children. In some subcultures, of course, the presence of any stigma at all is open to question. Thus we have not only the effect of a wage floor but, increasingly, of withdrawal from the work force by unskilled workers with a resulting labor "shortage" at the lower end of the skills level scale.

Where Do We Go from Here?

If we face a pattern of still steeper wage cost increases coupled with even greater scarcity of unskilled and semi-skilled labor, what kind of consequences can we expect? Perhaps the most difficult point for many operators to accept is that serious, fundamental changes in the way we do business are in the offing. This is difficult to accept because the hospitality industries are and have been anchored in our own traditions. It took a Memphis real estate

developer--Kemmons Wilson--to revolutionize the post-World War II lodging industry and a handful of inventive food service operators to develop the fast food concept.

Faced with innovative competition, a surprising number of operators have chosen to "stand and fight" on the lines of what they have seen to be their standards of service. While there is limited quantitative support for my position, it appears that the batting average of the traditional operator faced with innovative competition has not been particularly good over the past 25 years. A few outstanding operators have done very well. But the number of hotel rooms in operation declined from 1,550,000 in 1948 to 1,265,000 in 1972,¹¹ the countryside is littered with closed diners and family restaurants of an old model, and many prestigious "great" restaurants have experienced difficulty as well, often closing their doors.¹²

In the lodging industry, some of the difficulty may be attributable to the separation of the operator's knowledge of what must be done from the owner's decision-making power by the ignorance of many owners, informed as they are by a view of the lodging establishment as an investment without necessarily appreciating the operating realities which govern the long run success of that investment. Still, there are enough operators of a traditional cast of mind that they can hardly be excepted from a general statement regarding resistance to change.

If change is coming, what kinds of change may we expect? Some obvious changes in materials used are probably at hand as are major

changes in the equipment to handle whatever processes are required by the work of the establishment. More fundamentally, change in what we think of as service is almost certain to occur. What follows should not be thought of as "solutions" but rather as some preliminary speculations on the likely directions of change.

Changed Materials. If labor becomes both scarcer and much more expensive, the market for prepared foods is likely to expand. In general, it seems reasonable to assume that the large food processors' economy of scale advantages will become more pronounced as the hospitality industry's wage scale rises. As is already the case to a degree, moreover, lack of availability of unskilled labor--as well as its high cost--will force operators to move further and further toward the ready end of the raw-to-ready scale in purchasing. This larger market may increase competition in that area, hopefully resulting in improved quality and variety, and possibly--with major volume increases--reduction in prices. It is premature to predict the development of the food service establishment into a service-intensive retail outlet for manufactured goods, but this may serve as an approximate description of direction for some segments of the industry.

The increased use of disposable service seems virtually certain, particularly in the light of the improving quality of disposable ware. This development is, however, clearly bounded by environmental constraints, both as to scarcity of resources reflected in higher disposable ware prices and by disposal problems related to pollution. Increased concern with water quality may, however, operate to the

disadvantage of permanent ware and hence to the advantage of disposables.

Changed Equipment. Equipment changes that were not economically feasible five years ago may well offer significant cost savings in the labor market of five years from now. If the move to manufactured foods referred to above takes place, however, the principal on premise food service equipment changes may be expected to be related to materials handling systems dealing with the way product is moved from receiving into storage, from storage to the preparation or reconstitution station, and thence to the server or guest.

Perhaps the most important development in equipment will be in the capabilities of the industry's suppliers. The computer operated, small-scale food preparation systems,¹³ pioneered by European manufacturers, may make it quite possible that the structure of the prepared food manufacturing industry will change from one dominated by large companies to one in which company commissaries and commissaries operated by institutional food wholesalers serve a number of retail outlets in a relatively localized market.

Toward a New Concept of Service

If we are to think about serve in a constructive way in an age of exponential change in costs and availability of labor, we must change the set of questions we are asking in a fundamental way. We must shift from discussing what we are asking in a fundamental way. We must shift from discussing what we know to what we do not know. Discussions of service among industry people focus on alternations or

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reinforcements of traditional patterns of service and traditional service roles: "Bellmen carry bags and waitresses serve food. How can we change those processes to do them better or at lower cost?" These questions concentrate on what we know something about, but, from a systems analytic view, they begin at the wrong end of the process. Our question must become, "What satisfaction does the guest require in this process and how can we, without regard to traditional patterns, offer that satisfaction to the guest at a cost that is realistic. More simply, what is our objective, stated in terms of the guest's needs and wants?" This shift in orientation disposes of a lot of mental baggage but since the baggage, for most of us, is a lifetime of experience, it is hard to let go.

Jerome Vallen in his recent article, "Service: A New Definition,"¹⁴ stated the dilemma in economic terms. To paraphrase his point, it is an economic axiom that when the marginal utility (Satisfaction) per dollar is less for one good than for another, the consumer shifts his expenditures to the good with the higher economic utility per dollar. This is what has happened with service. With no real change in the absolute utility provided by personal service, the utility relative to non-service goods has dropped because of the failure of the hospitality industry to increase its productivity at the same pace as other industries.

While much of the evolution in service may be de-personalizing, it is equally possible that mechanization may make possible the "Re-personalization" of some service processes by eliminating time-consuming hand labor. We may be able to move from "rooming the guest"

as a physical process to "greeting the guest" in a way the guest perceives as satisfying, for instance. The key is in a shift from thinking of the traditional process to concentrating on the needs and wants of the guest as the starting point in our reasoning. It is clear that both labor cost and labor supply constraints are making impossible the delivery of traditional services in more and more operations. Rather than "whittle away" at the quality of service, it may be time to begin a basic redefinition of the process.

Notes

- ¹ John P. Henderson, Labor Market Institutions and Wages in the Lodging Industry, MSU Business Studies, 1965, Division of Research, Bureau of Business and Economic Research, Graduate School of Business Administration, Michigan State University, East Lansing, Michigan, p. 100.
- ² Social Security Bulletin, "Current Operating Statistics," December, 1972, p. 60. Unemployment benefits for many hotel and restaurant workers might be somewhat less than the average shown for all workers because in most states unemployment benefits have some relationship to the income of the worker when employed. Since employees in hotels and restaurants earn less, their employment benefit would probably be at the lower end of the range. On the other hand, average earnings shown in Figures 2 and 3 do not include tip income. Since something on the order of 15 to 20 percent of hotel and restaurant employees are tipped employees, the average income of hotel and restaurant workers may be somewhat understated.
- ³ Thomas F. Powers, "The Only Constant," Institutions Magazine, January, 1972, p. 34.
- ⁴ Theodore Levitt, "Production Line Approach to Service," Harvard Business Review, September-October 1972, p. 41.
- ⁵ Henderson, op. cit., p. 55.
- ⁶ Elizabeth F. Durbin, Welfare Income and Employment: An Economic Analysis of Family Choice, 1969, Praeger, 1969, p. 13-14.
- ⁷ Durbin, op. cit., p. 82.
- ⁸ Durbin, op. cit., pp. 13-19. For an interesting and current anecdotal description of the process by which AFDC affects male and teenage withdrawal from the work force, see Gary Hoeniz, "Turf," New York Times Magazine, Nov. 4, 1973, p. 73.
- ⁹ Why are New Yorkers Dropp-ng Out?," Monthly Economic Letter, Economics Department, First National City Bank, August, 1973, p. 13.
- ¹⁰ Durbin, op. cit., p. 11.
- ¹¹ Trends in the Hotel/Motel Business, 1973, Harris Kerr Forster & Co., p. 3.

- ¹²See, for instance, Bujarski, Pamela, "The Haute Cuisine Restaurants Here Up Against The Kitchen Wall," New York Times Magazine, February 20, 1972, p. 10.
- ¹³Werner Sell, "New Equipment and Systems in Mass Feeding," Journal of the American Dietetic Association, October, 1973, p. 413.
- ¹⁴Jerome J. Vallen, "Service: A New Definition," The Institute Journal, East Lansing: The American Hotel/Motel Educational Institute, December, 1972, p. 8.

The Impact of Productivity on the Service Restaurant

The market for the food service, it is widely accepted, is enhanced by increasing incomes, rising education levels and an increasingly widely traveled public. Evidence of a basic interest in fine foods is supplied by the substantial audiences attracted to television programs related to haute cuisine such as that of Julia Childs and "the Galloping Gourmet," as well as by the growing circulation of magazines such as Gourmet and a substantial increase in sales of wide varieties of cook books.

Service restaurants, however, must compete with alternate leisure and recreation choices. Equally importantly, the food service industry's ability to satisfy demand is basically a function of changing costs of the factors of production and of an emerging technology. The balance of this article explores data on productivity in various kinds of food service establishments and infers, from the change in the mix of restaurant types in operation since 1960, the direction in which the industry is moving. Finally, the potential impact of large quantity food production systems will be assessed as laying the ground for a move toward greater variety in food selection.

My particular concern is with the service restaurant. It will be appropriate to divide those in turn into two general groups, the luxury restaurant and the family restaurant. A separate kind of service system is found in cafeterias which are generally competitive with the family restaurant. Table 1 presents an operating profile developed by

Freshwater of 25 food service operations from data gathered in 1968 for cafeterias and in 1969 for restaurants. Six single line and six double line cafeterias, six family restaurants and seven luxury restaurants were reviewed.^{1,2}

As Table 1 indicates, the double line cafeterias differed from the family restaurants and single line cafeterias in being larger operations. All three economy operations, however, have roughly comparable check averages. Their food cost ranges between 35 percent and 38 percent, their payroll costs between 30 percent and 34 percent of sales.² The family restaurant, with a chair turn of 8.6 appears to make a more productive use of its physical facilities but, once again, in comparison with a chair turn of approximately five for cafeterias, there is a rough similarity in result.

These three economy style food service operations can be contrasted with the luxury restaurant whose dollar sales exceed those of the smaller economy food service establishments. This dollar volume is attained, however, with a much smaller number of guests--roughly one-third the number of guests served in the single line cafeteria or family restaurant. Clearly this result is achieved because of the higher selling price with a check average of approximately five times that experienced in the economy operations (not check average in 1969). On the other hand, the food cost lies within the approximate range of the economy establishment (at the upper end) while the payroll lies at the lower end of the scale for the other operations.

In choosing these operations, Freshwater and his colleagues specifically chose representatives of successful operations within each field. Clearly, then, these operations are ~~not~~⁵³ representative of all

TABLE 1

Operating Profile of 25 Food Service Operations

	<u>Single Line Cafeterias^a</u>	<u>Double Line Cafeterias^a</u>	<u>Family Type Restaurant^a</u>	<u>Luxury Restaurant^b</u>
Estimated Annual Sales	\$ 525,000	\$ 872,000	\$ 563,500	\$ 702,200 ^c
Average Daily Guest Count	1,260	2,136	1,290	381
Check Average	\$ 1.22	\$ 1.20	\$ 1.34	\$ 6.26
Food Cost % of Sales	38%	36%	35%	39%
Payroll % of Sales	30%	34%	32%	29%
Chair Turn/day	5.2	5.0	8.6	1.4

^a Average of Six Studied^b Average of Seven Studied^c Generally Lunch and Dinner only Served

Source: Agricultural Research Service

TABLE 2

Ratio of Productive Man Hours to Total Man Hours^c

	<u>Performance</u>
Single Line Cafeterias ^a	81.2
Double Line Cafeterias ^a	70.0
Family Type Restaurants ^a	77.9
Occasion Type Restaurants ^b	73.9

^a Average of Six Studied^b Average of Seven Studied^c Based on Work Sampling

Source: Agricultural Research Service

Table 1 actually understates the labor cost in service restaurants because it ignores tips paid by the guest directly to employees. If we assume no tips are given in cafeterias and a tip of 15 percent of the average tip is given in Family Type and Luxury restaurants and add that amount to both sales and payroll cost, a significant change in relative cost patterns results which is summarized below:

Table 1a

Establishment Type	Check Average without tip	Check average with tip	Wage bill without tip	Payroll % with- out tip	Wage bill with tip	Payroll % with tip
Single Line Cafeteria	\$1.22	\$1.22	.37	30%	.37	30%
Double Line Cafeteria	1.20	1.20	.41	34	.41	34
Family Type Restaurant	1.34	1.54	.43	32	.63	40
Luxury Restaurant	6.26	7.20	1.81	29	2.75	38

restaurants but rather represent relatively successful versions of these styles of operations.

Freshwater's studies focused on the ration of productive man hours to total man hours. Table 2 shows that the luxury restaurant had a productivity performance that is well within the range of the productivity of the economy style operations. Turning to Table 3, we begin to see drastic differences between the economy type restaurant and the luxury operation. Very clearly the labor requirements, across the board, are much more intensive for the luxury operation. The time consumed per hundred guests for cooking the more elaborate dishes in the luxury restaurant occupy something on the order of three times that of the more economical restaurant. The same is true for the salad department and for warewashing. Personal communication with Mr. Freshwater confirms the supposition raised by Table 2, namely that these variations in man-hour requirements are the result of more complex service and not of some lower efficiency that was not accounted for in the statistics. There is simply more silverware, more china and other utensils used in dining in this style restaurant than there is in the less elaborate economy class. Consequently, there is more work generated per guest in warewashing just as salads and cooked foods require more attention and man hours in this style of operation.

Similarly, in customer service it is possible to make rough comparisons between the family type restaurant and the cafeterias if serving and utility, and bus and tray labor in cafeterias are added together. (This does involve some inaccuracy since part of the work done by serving personnel in a cafeteria might be accounted for by pantry personnel in a conventional restaurant.) Cafeterias require

TABLE 3

Summary of Manhour Requirements for 25 Food Service Operations

Man hours per hundred guests required by

	<u>Single Line Cafeterias^a</u>	<u>Double Line Cafeterias^a</u>	<u>Family Type Restaurants^a</u>	<u>Luxury Restaurants^b</u>
Meat and Vegetable	3.30	2.90	3.85	13.89
Salad	1.20	1.02	1.44	5.23
Ware washing	3.10	2.86	3.47	11.75
Customer service	--	--	12.10	35.75
Serving & Utility	5.75	6.83	--	--
Bus & Tray	3.19	3.78	--	--
Bar	--	--	--	5.69
Bakery	<u>1.85</u>	<u>.96</u>	<u>--</u>	<u>--</u>
Total Direct Labor	18.39	18.35	20.86	72.31

^a Average of Six Studied^b Average of Seven Studied

Source: Agricultural Research Service

TABLE 4

Productivity in Food Service Establishments

<u>Food Service Type</u>	<u>Direct Labor</u> <u>Man Hours per Hundred Guests</u>
Luxury Restaurants ^a	72.3
Family Restaurants ^b	20.7
Cafeterias ^c	18.3
Fast Food ^d	10.5

^a Average of Seven Studied^b Average of Six Studied^c Average of Twelve Studied^d Average of Twelve Studied

Source: Agricultural Research Service

between 9 and 10 1/2 hours per hundred customers for service computed in this fashion compared with about 12 hours in a family type restaurant. The luxury restaurant requires nearly three times that amount of labor for serving or nearly 36 hours per hundred guests. Ignoring the amount of time required for bar operations, the luxury restaurant still requires well in excess of three times as many man hours per hundred guests as do any of the economy operations studied.

Table 4 presents summary data for the whole spectrum of food service operations including preliminary data supplied by Freshwater on Fast Food operations. As that data indicates, the fast food establishment with its extremely simple operating format requires half as many man hours per guest served as the family restaurant and one-seventh that of the luxury restaurant.³

The data that are presently available measuring changes, over time, in productivity in food service establishments, is unsatisfactory for any precise statement because of the large number of establishments with "no paid employees" (i.e., operated by the owner and his family) which report sales but no wages, thus distorting the relationship of wages to output by seriously understating the industry's total wage bill. The information available, however, supports the general conclusion of a zero change in productivity over the past ten years. The rate of sales per employee for the food service industry is the lowest in the United States economy.⁴ This assertion is based on data for the entire industry. Since there has been a very substantial increase in the number of fast food establishments in that 10-year period and these are known to be more highly productive, there is a reasonable presumption of an actual reduction in productivity since 1960 in the

balance of the (non fast food) restaurant industry. While wages have not risen any more rapidly in the food service industries than in other sectors of the economy,⁵ a zero productivity change compared with an average annual productivity change on the order of 4 percent in the rest of the economy builds a strong inflationary trend into the cost structure of the restaurant industry.

This strong inflationary bias appears to fall especially heavily on the luxury restaurant. Prices over a six year span at New York's very top restaurants rose approximately seventy percent. "On a broader sampling, at seventy of New York's finest restaurants the increase has amounted to perhaps 50 percent in six years."⁶ Since this study was published in early 1972 it does not take into account the recent steep price rises based on food cost changes and is largely the result of rising labor costs only.

Fine dining establishments of pre-World War II featured a labor intensity that is hardly available in the United States today. The old Ritz Carlton had a kitchen staff of 60 including five sauciers, with a waiter and waiter's assistant for every two tables and a captain of waiters for every four tables to assure perfection in service. The price of a typical meal in that establishment was \$3.50.⁷ Since that time, the size of kitchens has been drastically reduced even in the finest restaurants and in the vast majority of restaurants the number of choices available to the guests have been very drastically reduced. Recent trends in industry composition may shed some light on how fine dining establishment will fare as we move into the future.

Table 5 demonstrates that there has been a fairly limited growth in the total number of restaurants since 1960. This growth is more

TABLE 5

Change in Number of Firms,
United States Restaurant Industry 1960-1969

	<u>1960</u>	<u>1969</u>	<u>Change</u>
Restaurant and Specialty Food Units	247,000	254,000	+ 7,000
Fast Food Units	16,000	37,900	+ 11,900
Restaurants Other Than Fast Food	231,000	216,000	- 15,000
Fast Food Units % of Total Units	6.6%	14.9%	

Source: Economic Effects of Franchising

TABLE 6

Change in Number of Firms,
United States Restaurant Industry, 1960-1971 Estimated

	<u>1960</u>	<u>1971</u>	<u>Change</u>
Restaurant and Specialty Food Units	247,000	256,000*	+ 9,000
Fast Food Units	16,000	46,200*	+ 30,200
Restaurants Other Than Fast Food	231,000	209,800	- 21,200
Fast Food Units of Total Units	6.6%	18.0%	

Sources: Economic Effects of Franchising

* The Specialty Restaurant Industry
Hayden Stone, Inc.

than accounted for by the increase in the number of fast food units. The latest period for which definitive figures are available is 1969. From 1960 to 1969 there was an increase of only 7,000 restaurant operations in total while there was an increase of 21,500 fast food establishments, clearly indicating that the number of non fast food restaurants has actually declined from 1960 to 1969.⁸ Table 6 presents somewhat more provisional data based on an estimate provided by the security firm of Hayden Stone.⁹ Estimates of the number of establishments indicate an increase of 9,000 restaurants of all kinds from 1960 to 1971 and a provisional estimate of the number of fast food establishments, at 46,200, indicates an increase of 30,000 operations, nearly a 300-percent growth in the eleven-year period. The indicated decline in non-fast food restaurants of 15,000 establishments is a reduction of six and one-half percent of the 1960 total.

In looking earlier, at productivity rates, it was clear that, in a time of rising wage cost, in an industry with static productivity, the luxury restaurant confronts a difficult situation. Figure 5 presents an interesting case study. Figure 5a represents an operation which features a distinctive counter style fast service restaurant with the bare minimum of personal service available. Figure 5b presents a restaurant with moderate amounts of service but still not in the luxury class while Figure 5c presents the results of a luxury restaurant. (The three operations are located in the same city and owned by the same company). The information presented is shown in the form of an index with 1967 representing a base year. In the low service, counter style restaurant, the average cover remained relatively constant while the average wages per cover fell. Beginning in 1970, wage costs began to

skyrocket, and in 1971 it became necessary to begin to raise prices. With this price rise the average number of covers began to fall.

There was no "easy time" in the medium service configuration operation. Wages per cover increased in every year since the base year and the cost of an average cover also rose, and there was a modest reduction in the number of covers served over the time period.

In the luxury restaurant, wages per cover rose more steeply but prices rose slightly less quickly, perhaps because, here, the prices began at a higher absolute level than in the other two cases. In any case, the number of customers fell off substantially.

These three examples can not offer "proof" of anything. They serve to flesh out a line of reasoning, however, regarding the effect of the pressure of wages on prices. The pressure of wages on profits results in necessary price increases and when prices are increased, customers may choose, in a highly competitive market, to seek other alternatives. The question which arises is basically one of price elasticity of demand, and there is simply not enough data to tell us authoritatively the point at which rising prices will drive off more revenue than is earned by the price increase. In the case of the third (luxury) restaurant mentioned above, it can be reported that satisfactory profits are not being generated, and a review of the trade press or, for that matter, of the general business press indicates that the results being achieved in luxury operations across the country more and more approximate those of the third case: falling guest volume and a break-even or losing operation.

Productivity in luxury establishments is relatively low in terms of number of guests served; thus, the amount of labor added is clearly

what the customer is paying for. In a zero productivity change setting with rapidly rising wages, the result can only be rapidly increasing prices to the customer. It is an axiom of economics that when prices rise, the demand for goods declines. Thus, as prices in luxury restaurants increase relative to the general price level, we can expect these operations to be relying on a smaller and smaller portion of the population for their clientele. More generally, the successful table service restaurants which have been developed in recent years, like Steak and Brew, Emersons, or Steak and Ale, appear to rely on a fast food format for their success. By reducing the number of choices available to the guests they reduce the number of man-hours required in the kitchen drastically and simplify the work of the service personnel in the front of the house as well. Using a relatively low but consistent quality product (tenderized steak), these operations look very much like the table service restaurant of yesterday, but are, in fact, a stripped down version systemically more like McDonalds than a traditional restaurant. While it is useless to speculate on how long this particular format will be favored by the guests, the relative uniformity or lack of differentiation between operations may make it unusually subject to competition from innovative operators who discover a distinctively different format.

An alternative strategy for survival has been suggested for many years in the adoption of frozen prepared foods to reduce kitchen payroll and simplify operations. Four basic advantages of "manufactured" foods have been suggested. First of all, factory preparation eliminates "the built in inefficiency of the restaurant" in which production is contingent on the arrival and ordering behavior of the guest. Factory preparation

also offers significant economies of scale over even the largest commercial restaurants. The factory can also make more efficient use of joint products (such as the various cuts of meat on a carcass as well as trim, bones, etc.) Finally, the space costs of a factory are less, particularly those associated with land cost in typical manufacturing locations as contrasted with land and space costs in a good food service location.¹⁰

The frozen prepared food strategy, however, has presented a number of difficulties. Basically, operators have found that the quality of frozen foods available was often not acceptable to the better class of restaurant and the variety of quality products available has been entirely too limited. In general, the scale of production required for a frozen food plant or similar operation is such that a limited number of relatively standard products developed for a national market are the best that can be hoped for. This standard, often undistinguished, product combined with high transportation costs arising from shipping a refrigerated product across substantial distances makes for a product whose advantages are limited.

An alternative large scale production possibility is presented by the equipment systems developed in recent years by Europeans.¹¹ These equipment systems appear to offer the possibility of high quality small batch cookery using the best methods of freezing in a plant whose size, however, is such that it would logically serve a relatively smaller market and be able to offer wider variety. This equipment is presently being adopted in commissary operations for large state and county institutions and school lunch programs. In this country, the possibility that an institutional food wholesaler or restaurant chain commissary

would acquire such equipment in order for that firm to establish itself as a small scale, flexible manufacturer of frozen prepared food seems to be an idea whose time is about to come. Provided rigorous quality control measures are followed, experiments at the Cornell Hotel School, undertaken during the late sixties, clearly indicate that recipes for the very finest foods can be adapted for freezing.^{12,13} Work undertaken by the Army suggests that where a chilled rather than frozen food system can be used, superior quality in many products will result, providing the food can be served within 72 hours of preparation.¹⁴ Win Schuler Restaurants operate eight restaurants in Michigan and Indiana using a menu featuring a large number of centrally prepared foods, the majority of which are shipped chilled rather than frozen.

The European equipment referred to earlier, offers the potential flexibility to introduce an element of "custom design" in the manufacture of frozen prepared foods because of the feasibility of relatively short product runs (1000-10000 portions). Thus, the next turn of the wheel may see a resurgence of high quality and variety rather than one more step toward the all-purpose energy pill as the model of dining experience.

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Toward a View
of Industry Dynamics

Introduction

In the course of conducting this project, the author reviewed numerous articles and publications. Many of them are cited and described in this report; others were not judged to be helpful in the task at hand and are not cited at all. Clearly, then, this article does not constitute an effort toward an exhaustive review of the vast number of articles in the world of food service. Rather, it presents a highly selective review with emphasis on publications which are not a part of the restaurant trade press (though some articles from such publications are presented). Reliance on materials from outside the industry's "establishment" offer us a view of ourselves as others see us. Thus, the content of the article has been shaped not only by the author's interpretation of the literature he reviewed but as well as by the totality of that literature.

Gradually, the outlines of a view of the forces shaping the industry became clear. The balance of this essay presents an overview of these forces and relates them to particular articles which the author found helpful as he formed his views.

Supply Factors

The present age is seen as a "golden age of food supply," and

should continue for 25 or 30 years. More intensive cultivation, however, will be necessary to maintain these supply conditions. (Vickerey, 1) While new sources of protein are available in abundance from fish, leaves, plankton, bacteria, and petroleum, we face the cultural problem of keeping eating from becoming a neutral, automatic caloric intake. (Rey, 2)

Labor supply, on the other hand, presents immediate problems to the food service industry because of high turnover and low productivity. While the average annual productivity change in the United States is four percent, there is practically no change in productivity in the food service industry. (Kotschevar, 3)

A significant source of income to restaurant workers come from tips. For waiters and waitresses, however, the hourly income figures available suggest that a high average income for servers employed full time ranges between \$6,000 and \$7,000. (These estimates are based on a percent of employer food volume rather than employee income reporting, which may be subject to downward bias motivated by tax avoidance.)

(O'Connor, 4) Resistance to tipping may be increasing with the growth in packaged vacations and the increasing entry into the market of the cost-conscious traveler. (Anonymous, 5) One answer to the problem of tipping--and to the problem of the minimum wage--is the addition of a service charge. In some instances, the service charge has met with guest acceptance (Husser, 6), but there is also some evidence of guest resistance to service charges. (Anonymous, 5)

Fashion, Style and the Matter of Quality

Not surprisingly, traditional restaurants receive increasingly critical "reviews" as prices rise. Quality of service is seen as

extending beyond the server to practices related to tipping, "pushing" drinks, overbooking, credit card acceptance and the like. (Perham, 7) Lunch business is booming, but downtown dining spots face serious difficulties with the high tab dinner meal which is forcing many into relocation--or out of business. Some point to the possibility of an industry made up exclusively of fast food establishments and very expensive luxury restaurants. (Anonymous, 8) Others see a decrease in demand for formal dining as a result not only of rising prices but of shifting social customs as well. (Anonymous, 9) A significant number of well known fine dining establishments have closed their doors with factors cited including not only rising labor and product costs but also rapidly rising metropolitan rents and resultantly very rapidly rising restaurant prices. (Carruth, 10)

Fast food offers foods traditionally eaten by Americans (Anonymous, 11), with a shift beginning recently from hamburgers toward such newer entries as pizza (Anonymous, 12) and the very recent emergence of steak as a fast food! (Anonymous, 11) While the somewhat different "all you can eat" format presents an operator with problems, enticement to gorging is becoming an acceptable and successful marketing technique. (Anonymous, 13 and 14) The informal style of the merging popular restaurant often goes to extremes. (Anonymous, 15)

A definable American cuisine exists in an embryonic stage (Anonymous, 16), but the difficulties of delivering high quality food may require the combination of a high volume, popular priced operation with a more service intensive restaurant under the same roof, with two or three operations sharing a common production staff and facilities. (Anonymous, 17)

Ready Foods. One possible approach to making high quality cuisine an economically feasible product is found in frozen prepared foods. A great deal has been written in the trade press about the uses of frozen prepared foods but a series of experiments leading to the perfection of very high quality frozen prepared foods have been conducted at the Cornell Hotel School and may not have received the attention they deserve. The term "Ready Foods" was used as early as 1962 to denote foods which are partially or totally prepared. (Christian, 18) The concept advanced, however, to refer to foods prepared on premise by an operation thus maintaining their own quality standards and, ideally, achieving economies by concentrating expensive, skilled preparation labor in a narrow period while permitting expanded menu variety. (Sayles and MacLennan, 19) Considerable flexibility is offered by fairly lengthy storage times for high quality sauces, and specialized procedures have been developed for handling wine cookery, difficult products, and other special applications. Of particular importance is MacLennan's suggestion of replacing the volatiles by adding a small amount of the original volatile ingredient (for instance, wine) at the time of reconstitution. (MacLennan, 20 and 21) The development of Escoffier's recipes for the "Ready Foods" method suggests that unusually high quality foods can be prepared using these methods. While reports of commercial restaurants converting successfully to the "Ready Food" system were not noted, it is clear that this technique is coming into use in hospitals and institutions. (Sherck, 22)

Marketing

The food service industry has clearly entered the arena of national

marketing with the application of such sophisticated marketing techniques as test marketing in selected markets to determine the feasibility of a new menu item for a whole chain (Anonymous, 23); or testing an entire restaurant concept (Anonymous, 24); as well as to making increasing use of the experience gained in marketing by other non-food service retailers. (Anonymous, 25)

The cost of even a relatively uncomplicated television campaign at the national level is impressive. (Anonymous, 26) As smaller chains reach a certain size, they are able to enter the national advertising tourney and begin competing with national chains as well as the independent local operations. (Anonymous, 27 and 28) Smaller chains, however, are able to identify regional markets within which they can "take on" national competition with substantial use of the electronic media. (Anonymous, 29 and 30) Franchise groups are able to mount not only parent company campaigns but also to attract substantial matching expenditures in local markets supporting a national theme through expenditures of local affiliates. (Anonymous, 31)

The development of what is essentially a fast food format with the appearance of a full service restaurant--the format put forward by such growth chains as Steak and Ale, Steak and Brew, and Emersons--is really a marketing innovation rather than a technological innovation. (Anonymous, 32) The difficulties of competition in the media faced by the independent are not only related to a high dollar "entry level" but also to the conceptual and technical difficulties of media campaigns on the part of the independent operator. (Anonymous, 33 and 34) As one reviews articles on food service chains which use extensive advertising, particularly in the electronic media, he is struck by the

degree to which the 30 second or 60 second "commercial" format reinforces a simplified menu strategy.

In at least one case, operations research techniques have been found to be helpful in analyzing potential restaurant locations, existing restaurant locations, and existing restaurant performance with respect to location. (Sella, 35)

Fast Food and the Specialty Restaurant

With the development of large national chains, a new and valuable source of information is opened to the student of the Food Service Industry: security analyses prepared by major brokerage houses. Several large firms have developed analysts with expertise in the food service industry. (Anonymous, 36) Perhaps the best known and most successful fast food firm studied by security analysts is McDonalds, who have been successful in every market they have entered, with growth accounted for by both increasing number of units and increasing the average sales per unit. Food and payroll combined typically run just under 60 percent with the firm's expansion being virtually self-funding. (Brody, 37) The "specialty restaurant industry" follows a fast food format systematically but also includes coffee shops, dinner steak houses, and such miscellaneous specialty foods as pizza. (Reiss, 38) The typical fast food customer for fried chicken tends to be a working wife with children, an above average family income but only average social status, a yen for excitement and sociability rather than homemaking and is described as "a stereotype of our modern suburban housewife." (Tigert, Lathrop, and Bley, 39) Changing food consumption patterns are supported by rising education and income levels, greater mobility and leisure,

the growing number of working wives, and the development of technology and mass media. (Ullensvang, 40)

Some franchisees have become, themselves, large chains, as is the case with Gino's (Anonymous, 41) Applications of the fast food system are particularly appropriate to such entertainment complexes as Disney World. (Anonymous, 42) The food business continues to be a unique industry in spite of the simpler operating format of the fast food company. This is indicated by the failure of some conglomerates who have entered the hospitality business unsuccessfully. A good example is the unsuccessful attempt of General Foods to absorb Burger Chef. (Anonymous, 43 and 44) As food companies become large, national corporations, problems related to accounting policy, SEC regulations, and similar considerations become a part of the food service manager's set of problems. Accounting problems have been particularly troublesome to fast food franchising companies. (Anonymous, 45) The large companies have developed significant commitments to the international market and are well on their way to becoming multi-national firms. (Anonymous, 46, 47, and 48)

Some Views of the Future

Sales are increasing for the industry as a whole but the luxury restaurant is troubled by fear of violence at night, high prices, and a shift of population to the suburbs. The fast food franchise sector has had its troubles as well, including the substitution of a franchise concept for managerial talent, poor site choices, squabbles between franchisors and franchisees, and accounting irregularities. While the majority of fast food establishments are chain affiliated, 91 percent

of the luxury food establishments are independents. (Doty, 49) A quiet revolution is taking place in the restaurant industry basically similar in nature to the evolution of the grocery store from an independent neighborhood store to a chain operation marked by expanding sales volume, reduced customer services, and collective purchasing. (Smith, 50)

Changes anticipated include the increased use of computers and other non-human control systems and devices as well as preparation of foods on a large scale in local operations. (Willett, 51) The possibility exists of a completely automated, computerized restaurant in which the olfactory and visual environment is manipulated. Conveyors could move food to and dishes from the table quickly and automatically. (Avery, 52) A principal means of fighting changing cost patterns in the near and intermediate future is frozen prepared foods. (Califano and Weiss, 53) New kinds of food products may come to substitute for better known ones with increasing frequency as there is evidence that consumers are not only willing to accept artificial flavoring but have even come to prefer it! (Bralove, 54)

The food service industry is now and will continue to be experiencing a belated industrial revolution as it substitutes production line labor and capital for craft labor. Structural change is facilitated by a systems approach with possible emphasis on convenience foods. Some 50 percent of the units are currently reported to be using some convenience foods. (Perkins and Penn, 55) New delivery systems such as monorails are already having an impact on hospital food service (Walek, 56), but perhaps the most fundamental equipment change in view is found in

the European food production system referred to as the "cooking street," featuring large quantity, automated food production equipment in a commissary or quasi-factory setting. (Ronan, 57)

Toward a View of Industry Dynamics:

An Annotated Bibliography

Supply Factors

1. James R. Vickery. "Possible Developments in the Supply and Utilization of Food in the Next 50 years." Food Technology, (June, 1971), p. 55.

Changes in the utilization of food for the next 50 years should be able to be predicted fairly reliable since the nutritional, food, and agricultural sciences have been sufficiently developed to provide a firm basis for forecast. The present "golden age of food supplies" should continue for 25 to 30 years, until the pressure of population and economics begin to restrict dietary choice. There is a reasonable chance that food supplies will keep pace with demand, provided we greatly intensify agricultural production by using all available arable land; developing tropical and arid land; using selected animal breeds; utilizing protein source in the sea; and using single-cell protein for animal feed. These innovations will require the work of a wide range of skilled people. The protein-calorie malnutrition problem is most serious in children and is directly proportional to socio-economic conditions and disease patterns. Development of indigenous capacity to pay is of primary importance, for as family income rises, so does its protein intake per day.

2. Louis R. Rey. "The Role of Industry in Meeting the Challenge of Future Food Needs." Food Technology, 25, 26 (January 26, 1971), pp. 26-32.

As man's ability to feed himself has advanced, his involvement and satisfaction with the process has decreased. This presents a challenge to keep an agreeable and relaxing part of life from becoming a neutral, automatic caloric intake, of a mere biochemical and physiological nature. The article states the larger problem is to provide enough food for the peoples of the world. New sources of protein are seen as coming from Fish Protein Concentrate, extraction of protein from green leaves, exploitation of plankton, mass production of protein from monocellular organisms by fermentation, and controlled fermentation of pure petroleum derivatives.

As people become more concerned about health, they face the problem of knowing how food intake and nutritional habits affect physical and mental processes, central nervous system performance and social behavior.

Along with accepting the challenge to feed the world, the food industry is taking over a whole new field: a more biological approach to

the welfare and harmonious development of the human being.

3. Lendal H. Kotschevar. "Labor Shortage Intensified by High Turnover and Low Productivity." Hospitals, J.A.H.A., (May, 1972) p. 76

Dietary management is faced with the problems of finding adequate labor and controlling labor costs. Health care facilities, according to the author are understaffed by 4 percent in the food service worker category and by 7 percent in the professional dietitian category. In the decade previous to 1968, wages for food service workers had doubled to \$1.68 an hour. By 1980, the average wage for food service workers is projected to be \$3.50 per hour. High turnover among food service supervisors and workers is seen as another significant problem. Productivity in the food service industry is half that of other industries. While the annual productivity change in the United States is 4 percent, increases in productivity in food service are so miniscule as to be non-existent.

Kotschevar suggests that productivity may be increased through the use of prepared foods which reduce the amount of time necessary for preparation. These convenience foods, Kotschevar says, raise food costs by 5 percent while lowering labor costs by 10 percent. Productivity can further be increased by waste of labor. More training of food service workers can help increase productivity.

4. Charles M. O'Connor. "Wages and Tips in Restaurants and Hotels." Monthly Labor Review, (July, 1971), pp. 47-51

A survey of employees in restaurants and hotels covered by the Fair Labor Standards Act indicated that table waiters and waitresses were nearly all classified as tipped employees. In restaurants they averaged \$1.14 an hour in wages and \$1.80 in tips. Tips averaged substantially more in full course restaurants (\$1.93 an hour) compared to other types of restaurants (\$1.36 an hour), although wages were nearly the same (\$1.14 v. \$1.16, respectively). Waitresses, who outnumbered the waiters 4 1/2 to 1 on the survey, generally made less in tips in both the full course (\$1.78) and other (\$1.33) restaurants than the men (\$2.62 and \$1.65, respectively). Other tipped restaurant employees received substantially less. Bartenders averaged one dollar an hour in public bars in addition to hourly wages that ranged from \$2.21 in the South to \$3.06 in the East. Bus help earned \$1.43 an hour in wages and 42 cents an hour in tips (generally through a sharing arrangement with the waiters and waitresses) in full course restaurants and \$1.54 an hour plus 12 cents in tips in other restaurants. Bellmen earned \$1.23 an hour in wages and \$1.18 in tips.

5. Anon. "Tipping: Travel's Tedious Tax." Cornell Hotel and Restaurant Quarterly, Vol. 8 (February, 1968), pp. 43-50.

The cost of packaged trips often does not include gratuities. Tips are resented when they come as a surprise after the guest thinks he has determined his vacation cost in advance. This problem is increasingly acute among the growing number of budget-conscious purchasers of packaged

vacations from the lower middle income and young age groups recently entering the travel market. Tipping is of greater significance to waiters, waitresses, and bellmen than to other hotel and restaurant employees. For those who receive them, tips are often largely tax free because of under-reporting. The tip began as a means of offsetting a low wage, and the tip credit provisions of the minimum wage law perpetuates that discrepancy. One way to eliminate tipping is the institution of a service charge. There is some evidence, however, of guest preference for voluntary tipping and resistance to a service charge.

6. R. D. Musser. "Answer to the Tipping Problem." Cornell Hotel and Restaurant Quarterly, Vol. 8 (February, 1968), pp. 99-101.

The author discusses the no-tipping system instituted at the Grand Hotel, a resort hotel that caters to conventions, on MacKinac Island between Lake Michigan and Lake Huron. The no-tipping system was introduced in an effort to deal with a stringent minimum wage passed by the Michigan Legislature in 1964. The system was designed to provide salary credits for room and board provided by the resort to its employees.

The system involves an automatic 15 percent service surcharge on all guest bills. Employees are paid a small salary and are given an incentive pay to maintain quality service. Reaction by patrons to the no-tipping system has been highly favorable and employees make the same money as they did before the no-tipping policy. While payroll has increased from \$350,000 in 1964 to \$850,000 in 1968, the increase has been offset by employee payments for room and board and collections from the 15% service charge.

Fashion, Style and the Matter of Quality

7. John C. Perham. "The Restaurants That Executives Hate." Duns Review, (December, 1972), pp. 57-59.

Top business executives are giving vent to their feelings about the current state of fine dining. Despite company expense accounts, executives are appalled at the dramatic price increases at top restaurants. Exacerbating the situation is the selectivity of luxury restaurants about credit cards they will accept, with many of the most expensive refusing to accept any. Businessmen find many of the same restaurants "complacent and sloppy" with neither food nor service comparable to their prices. Further, the short shrift given the non-drinking customer and the intense pressure applied by restaurant staff to tip heavily is especially rankling to the businessmen interviewed. Finally, some luxury restaurants tend to overbook reservations--sometimes meaning waits of over two hours. The feeling among top executives is that fine dining is becoming an increasingly rare pleasure.

8. Anon. "Dining Out in America - How Old Ways are Changing." U. S. News and World Report, (April 20, 1970), pp. 92-94.

Dining out is undergoing change that has a profound impact on the restaurant business. Lunch-time business is booming, but at night, downtown restaurants are empty, forcing many to close or relocate. With money so tight these days, most families can no longer afford the luxury of eating out. Those who can, patronize either suburban restaurants or less expensive, fast food services. Rising cost prices and the difficulty of finding and keeping reliable help also hurt the restaurant business. In the future, we may see only the elegant restaurant and the franchise, fast-service type, with nothing in between.

9. Anon. "Toast Farewell to the Two Hour, Seven Course Dinner." Advertising Age, (October, 1971), p. 45.

The retreat and eventual abandonment of the full course dinner is seen by the author as a result of shifting social customs and habits and severe economic pressures on the restaurant industry. The declining tendency of the family to eat as a unit, the trend toward consumption of less food on an increasing number of occasions during the day--all suggests the demise of the full course dinner menu. A generation weaned on fast foods is liable to view the formal dinner with positive aversion. Increasing labor and food costs have almost completely undermined the economic viability of the full course dinner menu.

The article foresees the replacement of the full course dinner menu with a limited selection of entrees of high quality much in the same manner of the abbreviated menus of France's four-and three-star restaurants.

10. Eleanore Carruth. "Restauranteers Need Some Recipes for Survival." Fortune, (March, 1972), p. 91.

A large number of fine restaurants have closed their doors and some are speaking of the end of an era. This development is noticeable not only in New York but in 15 major cities studied across the United States. The difficulties of the fine dining establishment are attributed to exploding labor costs, union pressures, limited or zero growth in productivity, rising raw product costs with meat and fish showing the greatest rise. For downtown restaurants a significant pressure is that of ballooning real estate values with the square foot rental charge of \$6.50 in one area going to \$40 when the old buildings were replaced with new ones. In six years, there has been a 70% increase in prix fixe menus at New York's very top restaurants while a 50% increase was noted in a broader sampling of 70 "good to finest" New York restaurants. Changing styles make the formal restaurant seem "passe" to many operators and customers.

11. Anon. "The Roadside Gourmet: Pop Goes the Food." Newsweek, (September 25, 1972), pp. 76-78.

In 1971 there were 35,547 franchised fast food outlets throughout the United States with a gross of \$5.3 billion. Projections for 1972 indicate a 22 percent increase to \$6.5 billion. The franchise fast food outlet or "pop" restaurant is characterized by inexpensive prices and produce uniformity. According to this article, items of pop restaurants

are nothing new. "Pop" restaurants cater to the traditional American taste for hamburgers, hot dogs, fried chicken, and ice cream. Exceptions are relatively new items such as tacos, pizza, and steak. Pop food's emphasis is on the slick packaging of old staples and the employment of the most modern marketing and merchandising techniques.

The newest twist in the fast foods industry is the steak house. Characterized by the same standardized, strictly limited menu, the steak house offers up a more luxurious decor and higher prices. The history of the fast foods industry has been one of heady growth. Yet with many areas now saturated with franchises, rapid expansion seems less likely. Furthermore, there appears to be an incipient revolt of franchise owners who are claiming that the parent corporations elevate prices and restrain trade by requiring them to buy standardized products. Yet with a one-fifth share of the \$30 billion that Americans spend for food in all hotels and restaurants, the "pop" restaurant industry's future seems bright.

12. Anon. "A Palate Revolution." Forbes, (February 15, 1971), pp. 35,37.

This article deals with the growing popularity of pizza with the American palate and its importance in the fast foods industry. According to a recent Gallup Poll commissioned by Food Service Magazine, the 21 to 34 age group has switched allegiance from hamburgers to pizza. Demonstrating the growing popularity of pizza is the growth of Pizza Hut, Inc. of Wichita, Kansas, with 700 stores and sales of \$22 million and the largest of the chains, Shakey's owned by Great Western Stores, with 350 stores and sales of \$68 million a year.

While pizza is not a true fast food item--it takes 12 to 15 minutes to prepare--technological innovations such as frozen pizza buns (Losurdo Bros. of Moonachie, New Jersey) which when thawed become dough for an oven fresh pizza are speeding up preparation. Frozen pizza sales are also expanding with Grand Union supermarkets reporting an annual doubling of sales and Kraftco, Inc. ready to make a major entry into the frozen pizza market.

13. Anon. "The Importance of Being Greedy." Time, (October 23, 1972), p. 72.

The article describes the trials and tribulations of the "all you can eat" restaurant, like the Howard Johnsons's Restaurant in Spring Valley, New York, where high school students arrived on one chicken night (all the chicken you can eat for \$1.69) and consumed 360 pieces of chicken (90 pounds). Some establishments see the person who eats too much as excellent advertising.

In addition to catering to galloping gourmards, restaurants that offer unlimited seconds have to deal with individuals who smuggle out food. A manager of a Shakey's Pizza Parlour in California discovered a patron walking out with 200 pieces of chicken stashed in a guitar case. Despite these difficulties, the "all you can eat" theme seems to be gaining in popularity throughout the restaurant industry.

14. Anon. "All You Can't Eat." Newsweek, (October 8, 1973), pp. 89-90.

The popularity of buffets and smorgasbords with the eating public has increased dramatically over the past few years. Restaurants specializing in "all you can eat specials," threatened by sky-rocketing food costs have had to tighten their belts. Howard Johnson's new approach advertises "seconds on the house" rather than "all you can eat." Some restaurants have been forced out of business while others have had to raise prices as much as 15 percent since the first of the year.

15. Anon. "Waiters on Wheel." Newsweek. (December 11, 1972), p. 116.

Putting waiters on roller skates may be the answer to increasing waiter productivity with two Eastern restaurants pointing the way. The owners of La Nicoise, a French bistro in Washington, D.C., hoping to dispel the traditional stuffiness of French restaurants, placed their serving staff on skates for the dinner shift. Accidents are few, but on one occasion a chocolate mousse was dropped on a senator. An added attraction is an hour of cabaret held nightly performed by waiters and maitre d'--all on roller skates.

The latest entry into the restaurant roller derby is the Eighth Street Gallery, a pub-like restaurant owned by the Horn and Hardart chain. Roller skating waiters were introduced as a zany come-on, but the gimmick has proved to be a practical innovation.

16. Anon. "Is There Really an American Cuisine?" Saturday Review/World, (November 20, 1973), pp. 28-35.

This article is a collection of writings describing the contribution made by various regional kitchens to the emerging American cuisine. American cooks have adapted cooking skills brought from the Old World and those learned from the Indians to utilize the new and strange native foods; they have also created new cooking, baking, and preserving methods. From a blending of the food habits of many peoples, there is emerging a true and recognizable American cuisine.

17. Anon. "Kennedy Center: 3 in 1 Combo." Institutions/Volume Feeding, 70 (May 1, 1972), pp. 68-69.

Coordination is the key to the Canteen Corporation's operation of the Kennedy Center's three restaurants--Promenade Buffeteria (a cafeteria), The Gallery (an intimate cafe), and LaGrande Scene (haute cuisine). All meals (over 10,000 a week) are prepared in one ultra modern kitchen equipped with two especially designed tilting braising pans with cooking areas up to 12 square feet and self generating heating units. Quality standards for food are identical in all three restaurants.

An example of the meticulous coordination involved in Canteen's operation is seen in the red snapper with lobster served at La Grande Scene that, with the addition of shrimp and scallops, becomes the Seafood Newburg for the Gallery. The ends of the snapper are utilized in the

creole sauce for the cafeteria. To insure top quality in the cafeteria operation, policy requires that at least one of the chefs eats a meal in the cafeteria each day. Executive chef Claude Bouchet inspects the cafeteria line each morning. Staffing requirements for the three restaurant operations include a cooking and preparation staff of 25 under the Executive Chef, 30 in cleaning and maintenance, 35 waiters and cocktail waitresses.

18. Vance A. Christian. "Ready Food Research at Cornell." The Cornell Hotel and Restaurant Administration Quarterly, 3:1 (May, 1962), pp. 14-15.

Christian reports on a survey conducted by the School of Hotel Administration at Cornell University on the production of "Ready Foods" by food manufacturers for the hotel, restaurant, and institutional market. "Ready Foods" are menu items that are either partially or totally prepared and require only one production operation for serving.

A research program was established to examine the factors of cost, preparation methods, and customer acceptance of "Ready Foods". The goal of the study is seen as determining the utility of "Ready Foods" in helping the hotel and restaurant industry deal with the problems of increasing labor, food and equipment costs, and the lack of skilled cooking personnel.

19. C. I. Sayles and H.A. MacLennan. "Ready Foods: The Application of Mass Production to a La Carte Food Service Using Prepared-To-Order Food." The Cornell Hotel and Restaurant Administration Quarterly, 6:12, (August, 1965), p. 21

A rising wage scale, increased food costs, low labor productivity, and lack of skilled help are the difficulties with which the food service industry as a whole must deal. They are especially critical to food service operations in hotels and in high quality restaurants. This article is a preliminary report on a research project undertaken by the Cornell School of Hotel Administration called "Ready Foods--The Application of Mass Production to a la Carte Food Service Using Prepared to Order Food." "Ready Foods," according to the article, is a term applied to food that has been processed to the point where it can be kept for a convenient period of storage. Such processing includes packaging the food in individual portions.

Advantages of "Ready Foods" are numerous and center on the economies of mass production. One highly skilled chef can supervise mass production of "Ready Foods" with less highly trained cooks doing the actual work. "Ready Foods" allow menu expansion at a minimum additional cost and allow resort hotels and other hotels with seasonal peaks and valleys in occupancy to utilize their facilities more efficiently. "Ready Foods" offer hotel restaurant operations the opportunity to increase sales volume and profits as well as to institute more effective inventory and cost controls. Included in the article are a list of 33 "Ready Food" items with portion cost information for various appetizers, entrees, and desserts.

20. H. Alexander MacLennan. "Ready Foods Research Advances at Cornell." Cornell Hotel and Restaurant Administration Quarterly, 8:1 (May, 1967), pp. 114-116.

The article states that a combination of increased labor costs and scarcity of skilled culinary personnel has resulted in the limited menu consisting of easily prepared roasts and grilled items--augmented by a few pre-cooked frozen foods--purchased from food processors. The Ready Foods concept of on-premises mass production of menu items which are then individually portioned and frozen for future use is suggested as an alternative to the receding menu--a menu of even fewer choices.

Research done by the Cornell School of Hotel Administration on the adaptability of various food items to the Ready Foods Process indicates that bases may be stored for up to three months with no loss of quality. Basic sauces may be kept for up to five weeks. The best procedure for recipes requiring wine is to add half the allotted amount of wine before packaging and freezing and the remainder during reconstitution. Such foods as french fried potatoes or eggplants should be partially deep fat fried before packaging and freezing. During reconstitution, the items should be immersed in deep fat, allowing the thawing, heating, and cooking processes to continue simultaneously. The use of Ready Foods in a demonstration by the Cornell School of Hotel Administration suggests that a 27.2 percent departmental profit on hotel restaurant operations (without the aid of the banquet trade) is possible as a result of the utilization of Ready Foods.

21. H. Alexander MacLennan. "Ready Foods." The Cornell Hotel and Restaurant Quarterly, 8:14 (February, 1968), pp. 56-68.

MacLennan foresees the introduction of the Ready Foods concept as a remedy for the mounting red ink, the decline in food quality, and the radical reduction in menu selections in hotel food service operations. Ready Foods are distinguished from convenience and other prepared foods by several factors. Preparation is in large quantities and performed on the premises. As no more than three or four foods are prepared in any one day, there can be complete supervision by the master chef, a return to classical cooking methods, and no need for synthetics or food additives. Freezing is employed as the method of preservation and storage, so serving requires a simplified reheating process. Single portion packaging prevents the quality deterioration that normally accompanies long periods on a steam table. Ready Foods prepared and packaged on premises can also accommodate local tastes and different portion sizes.

The adaptability of Ready Foods to the demands of haute cuisine is supported by the use of recipes by Escoffier in testing the viability of the Ready Foods concept. Start up costs for the implementation of the Ready Foods concept involves purchase of a blast freezer, increased zero degree refrigeration storage areas, some reheating equipment, and larger food inventories. Ready Foods, through mass production, reduces both food costs and labor costs per portion and helps avoid food wastage. Menus can be expanded at minimal costs, and such high profit items as appetizers, soups, and desserts can receive greater promotion. One master chef can oversee the entire program of food production and

exercise close supervision of the few items prepared each day. Classical recipes or the chef's own recipes can be incorporated, and all recipes can start with fresh foods. Local tastes can be catered to more readily. Finally, greater accuracy can be attained in cost figures for food production and inventory control.

22. Charles K. Sherck, "Changes in Food Consumption Patterns." Food Technology, 25 (September, 1971), pp. 50-52.

The author examines changes in food consumption patterns. Currently the food service segment of the food industry (both institutional and restaurant) accounts for 30 percent of the American consumer's food dollar, and this figure is expected to increase to 50 percent. Within the institutional market, rising labor costs and lack of trained food service personnel have caused a marked increase in the use of convenience foods, frozen entrees, premade individually wrapped sandwiches, and other pre-prepared items. A growing trend in hospital feeding is the elimination of food preparation as a part of the hospital function. Food is prepared in individual servings off site, then shipped to the hospital where it is reheated in microwave ovens. School lunches are expected to increase from 4 billion to 8 billion by 1976. Within the restaurant sector of the food service industry, fast food outlets show the fastest rate of growth.

Socio-economic trends that will affect the food service industry include educational level, income, travel, urbanization, leisure activities, number of housewives working, disappearance of the family meal, and disappearance of the three-meal-per-day regimen. Emphasis on the slim trim look by the young and educated, concern for health, and increasing emphasis on nutrition and nutrition education will also have major impacts on the food service industry.

Marketing

23. Anon. "McDonald's for Breakfast? We're Working On It." Advertising Age, 43 (September 11, 1972), p. 52.

McDonald's, the hamburger fast food franchiser, has begun test marketing breakfast at some of its outlets located in Chicago, Pittsburgh, and Washington. The new menu item is a fried egg served on a muffin. The article suggests that it is doubtful that it will be seen nationally at every McDonald's outlet as there are over 2,000 outlets and some franchisees may reject menu additions. Another addition to the McDonald's menu is the Tripple Ripple, a three flavored cone, frozen hard enough so that it can be purchased with the rest of the meal and be soft enough to eat when it is time for dessert.

24. Anon. "General Mills Open First Betty Crocker Restaurant in Dallas." Advertising Age, 40 (July 28, 1969), p. 74.

General Mills is opening the first of its Betty Crocker Tree House Restaurant and Bake Shops in Dallas in November, 1969. Four additional test restaurants are planned for openings by June, 1970, in various parts

of the country. The Dallas operation will sell various baked goods and 20 different kinds of cookies and will include a cater-counter to sell takeout foods for lunches.

25. Anon. "Pre-printed Coupon Insert Results Told." Editorial Publisher, 104 (July 24, 1971), pp. 31-32.

The article outlines in detail the use of the pre-printed coupon insert advertising campaign conducted for Arby's Roast Beef Restaurants. The campaign centered on getting the customer to try an Arby's roast beef sandwich. To this end, he was induced by the offer of a free milk shake with each sandwich purchase and a coupon. The campaign had a 20 percent response.

26. Anon. "Burger King Drive Has \$1,000,000 Promotion Tag." Advertising Age, 42 (September 13, 1971), p. 2.

Burger King Corporation has budgeted \$1,000,000 for a Saturday morning and prime time series advertising campaign. The network drive will be primarily directed toward a Saturday children's series and will introduce a new animated consumer spokesman dubbed "The Burger King" and a new theme "where kids are king." In addition, six million theme book covers will be distributed. This new campaign indicates a shift in emphasis from the adult market to the children's market. Burger King entered network TV in the spring of 1971.

27. Anon. "Pizza Hut Has Basketball in '72 Ad Plans." Advertising Age, 43 (April 17, 1972), p. 85.

Pizza Hut, Inc. moves into national advertising with plans for 1972 centered on sports and especially on its sponsorship of a college all-star basketball classic carried by 120 TV stations across the country. Computerized ballots are available in local Pizza Huts. The special will include 18 minutes of commercials. Pizza Hut, Inc. is relatively new to national advertising; its first campaign began in 1970.

28. Anon. "Shakey's Opens Its Big Ad Guns on Hamburgers, Chicken." Advertising Age, 42 (December 27, 1971), p. 3

Shakey's Pizza Parlors mounts a new advertising campaign designed as a frontal attack on the two leaders in the fast food business, McDonald's and Kentucky Fried Chicken. The strategy is to allow these two giants, with advertising budgets of \$25 million and \$10 million respectively, to convince the American family to go out and eat, at which point Shakey's hopes to persuade the family that there are better alternatives to hamburgers and chicken. The 1972 budget is set at \$3 million.

The theme of the ad campaign, "Shakey's Feeds You Fun," projects Shakey's as a cross between a family eating place and a beer hall with heavy Gay 90's motif.

29. Anon. "Church's Initial Campaign Tests in Dallas--Fort Worth." Advertising Age, 44 (June 25, 1972), p. 31.

Church's Fried Chicken, Inc., with 500 outlets in 23 states will launch its first advertising campaign in June of 1973. Church's distribution strength is mainly in the Southeast and Southwest. The initial test will utilize radio and TV in the Dallas-Fort Worth area. The theme of the advertising campaign will be "The golden test of Church's comes ringing through." Text expenditures are expected to exceed \$200,000 in a 12-month period.

30. Anon. "Pup 'N' Taco TV Stresses 'Fun' Image." Advertising Age, 42 (September 7, 1971), p. 18.

Pup 'n' Taco Drive Up, operator of 50 fast food outlets in the Los Angeles area, initiated a \$100,000, five-week TV spot campaign oriented towards promoting hot dogs and tacos as fun to eat. Hot dogs are seen as associated with such "good times" as ball games, picnics, and circuses. This is the chain's first major advertising campaign.

31. Anon. "International Pancake House TV Spots Use Grid Action." Advertising Age, 42 (September 27, 1971), p. 8.

International House of Pancakes, Inc. initiated an advertising campaign for the 1971 football season, to promote sales of official miniature helmets at participating restaurants in the national chain. Television spots in 90 markets plus full page advertisements in Boys Life and Scholastic will be employed. Seven advertising agencies served cooperative groups of franchise owners in coordinating and supplementing national materials. Budgeted expenditures for the International House of Pancakes advertising program in 1971 were \$1,000,000, and \$10,800,000 when local cooperative efforts were added.

32. Anon. "New Concepts Work for Steak and Brew." Advertising Age, 44 (April 9, 1973), p. 46.

The success of Longchamps, Inc.'s Steak and Brew chain, which has expanded to 50 locations within the heavily populated East Coast corridor, can be, according to the article, attributed to its emphasis on the preferences and budgets of the young. Steak and Brew outlets are designed with an English pub motif and with heavy emphasis on informality--"a casual place where you can almost hang out." The menu is limited so that the check won't get out of hand. Furthermore, Steak and Brew employs the concept of unlimited bread and salad, plus all the beer, wine, or sangria a person can drink. As a result, Steak and Brew's clientele is the young, the working class family, and surprisingly, the upper class at leisure time. Average sales for the 29 company-owned units is \$950,000--all at locations where restaurants had previously failed.

33. Anon. "Two Admen Customers of Tea Room Create Ads for Owner, Fee is Food." Advertising Age, 40 (November 10, 1969), pp. 78,80.

This article discusses an advertising campaign for a mid-Manhattan restaurant, the Russian Tea Room. The campaign was designed to change the image of the restaurant from that of finger sandwiches and

petits fours to that of a sophisticated specialty restaurant. Full page ads in the New York Times emphasized menu entrees, and the reaction has been impressive. The campaign was created by two advertising firm executives as a "due bill" arrangement (that is, in return for food and services from the restaurant).

34. Anon. "Customers Know More About You: Are You Learning About Them?" Institutions, (April 15, 1973), pp. 68-79.

Patron research often deals with demographics rather than patron attitudes. New research services can expand these boundaries with such methods as a patron dairy approach or behavioral research. A customer's reasons for his choice are often multiple and complex. Food services can only benefit from a fuller knowledge of the customers and their preferences.

Burger Biggie, a carry-out franchise chain, found that its position of area dominance was beginning to decline. Using market segmentation to get at the causes of then decaying popularity, they were able to define cleanliness and high prices as the areas needing improvement. They embarked on a program of positive corrective action and subsequently began to regain the market. Market segmentation can be effective not only in such defensive action, but also to probe the market ability of new concepts or new avenues for existing operations.

35. Francis R. Salla. "Computer Evaluation of the Restaurant Site." Cornell Hotel and Restaurant Quarterly, (November, 1968), pp. 25-31.

This article reports the use of a computerized mathematical model to aid in site selection. Quantitatively, factors incorporated in this model include population, income, advertising budget, number of competitors, and traffic volume. Qualitative factors such as neighborhood characteristics, ability of the manager, and site visibility are quantified with a 1 - to - 10 scale. Five models were originally constructed for (1) general restaurants, (2) drive-ins, (3) hamburger places, (4) cafeterias, and (5) specialty restaurants. Subsequently a sixth model for highway restaurants was developed, and specialized models were constructed for a number of franchised restaurants. Actual empirical values (such as traffic count: 12,000; the number of parking places; or distances to motels) are substituted in a complex set of equations. Computer solution of these equations results in a dollar volume prediction that has so far been highly accurate. The model is useful not only in selecting new sites, but also in evaluating current operations and analyzing potential for new volume. The accuracy of the input data is of critical importance.

D. Fast Food and The Specialty Restaurant

36. Anon. "Restaurant Industry." The Wall Street Transcript, XLII: 7 (November 12, 1973), pp. 34929-25008.

A round table discussion presents the views of five security analysts

who have specialized in the restaurant industry. The participants are Alice J. Bradie (Paine, Webber, Jackson and Curtis, Inc.), Carl F. DeBiase (Moore and Sehley, Cameron and Co.), Richard Reiss, Jr., (Hayden Stone, Inc.), Alfred L. Simon (Sanford C. Bernstein and Co.), and Janet W. Tanner, (Aetna Life and Casualty Insurance Group).

37. Alice J. Brody. "MacDonald's: A Security Analysis." Research Department, Paine, Webber, Jackson and Curtis (1973)

Virtually every market MacDonald's has entered, from rural to urban, has proved successful and now accounts for an 11 percent growth compounded since 1961. Revenues are derived from licenses, rentals, service fees, and operations. Food sales estimates are accounted for as follows: hamburgers, 49 percent; french fries, 15 percent; fish sandwiches, 7 percent; beverages, 23 percent; and desserts, 6 percent. Food costs typically range from 36.5 percent to 37.5 percent of sales. Daily inventory assists in maintaining minimum waste. Payroll, assuming a \$2.00 minimum wage, is \$300 per day with payroll cost accounting for approximately 21 percent of sales. Advertising and promotion requires 4.5 percent of sales with 1 percent going for national advertising and .5 percent for in store promotion. Prospects for MacDonald's continued growth in sales and profits appear bright, but the fast food competitive environment is becoming increasingly more difficult with only the best run firms surviving. MacDonald's expansion is seen as virtually self-funding because of high profits and favorable cash flow.

38. Richard Reiss, Jr. The Specialty Restaurant Industry. Research Department, Hayden Stone, Inc., (February, 1973).

Reiss sees the specialty restaurant as having four basic sets of characteristics: (1) common ownership bonds; (2) centralized control with decentralized management; (3) easily recognizable, proven format; and (4) competitive prices, limited menus, and low labor content. Within the overall specialty restaurant format, he sees four categories: (1) fast food, (2) coffee shops, (3) dinner houses, and (4) miscellaneous. Six facts are crucial to the success of a specialty restaurant: (1) real estate and site selection and development expertise; (2) access to permanent capital for new unit expansion; (3) creation of material or regional franchise (brand) through standardization of operating procedures and standards, national, regional, and local advertising and marketing; (4) superior management training and compensation programs; (5) strict operating and financial control procedures; and (6) the discipline to stay with a proven operating format and restrict expansion to manageable proportions. Reiss reviews five firms in depth: MacDonald's, Sambo's, and Pizza Corporation of America, Denny's and Emersons's Ltd.

39. Douglas J. Tigert, Richard Lathrop, and Michael Bley. The Fast Food Franchise. Journal of Retailing, (Spring, 1971), pp. 81-90.

In January, 1969, a 25-page questionnaire was mailed to a panel of 1000 homemakers. The 85 percent returns gave information on fast

food chicken purchases, and a well-defined demographic profile of the heavy user emerged: a full-time worker; young; in a family with slightly more children than the sample's average; and in a family with a significantly higher family income than sample average but with average educational and occupational status. Further, data regarding life style indicate a homemaker who seeks excitement, is concerned with how she looks, is less concerned about homemaking and cooking, is not particularly oriented toward her home and children, and is active socially. The authors conclude that "she is the stereotype of our modern, suburban housewife."

40. Leon P. Ullensvang. "Food consumption Patterns in the 70's." Vital Speeches of the Day, 1970, pp. 240-246.

The past decade has been a period of remarkable change, especially evident in our changing food patterns. The consensus prognosis for the 1970's is continued change. Rising education and income levels, greater mobility and leisure, the growing number of working wives and the development of technology and mass media will all have a tremendous impact on our food habits. Family meal patterns are rapidly changing while the quest for convenience and greater diversity continue. The ways in which food is acquired and prepared are also changing, with growth occurring in large chain units, small convenience stores and away from home feeding.

The basic forces which will affect product success in the future are hedonic satisfaction, convenience, changing meal patterns, and eagerness to try new products regardless of their origin. Consumer needs will be more intellectual, reflecting new life styles and the affluent mentality. Marketers must be quick to spot changes, interpret them into meaningful products and services and deliver these products in such a way as to elicit positive responses.

41. Anon. "Record Results on the Menu." Financial World, (May 16, 1973), p. 23.

One firm that has successfully capitalized on the fame of its owner is that of Gino's, Inc. owned in part by Gino Marchetti, a star defensive end with Baltimore Colts. The company which has 342 units, all company owned, is located mainly in Maryland, eastern Pennsylvania, Delaware, New Jersey, and the Washington, D.C. area. Its menu consists of Colonel Sander's Kentucky fried chicken, hamburgers, and other complementary fast food items. Sales in 1972 were 128 million dollars.

Attempted expansion into Connecticut and the highly competitive Los Angeles market resulted in a 1.8 million dollar loss when the company divested itself of the 21 unprofitable units in these states in 1971. Gino's now concentrates on its mid-Atlantic market. Expansion plans center on Rustler Steak Houses, economy steak houses, and encouraging results with the 22 units presently in operation have led the company to project the opening of 200 additional Rustler restaurants in 1974 and 1975. First quarter earnings in 1973 were a 43 percent year-to-year advance on a 25 percent sale gain.

42. Anon. "FF Helps Feed Vacationers at Disney World Complex." Quick Frozen Foods, (February, 1972), p. 35.

Disney World, the \$400 million entertainment complex about 20 miles southwest of Orlando, Florida is the fast food company's Nirvana. Designed to be self-contained, Disney World will include five hotels and enough restaurants to feed the thousands of hungry tourists expected to stream through the entertainment complex when Phase I of its building program is completed. Fast food companies already involved are the kitchens of Sara Lee which operates an old fashioned bake shop on Main Street U.S.A. and the Florida citrus industry through its Sunshine Pavilion.

43. Anon. "The Bigger They Are..." Forbes (February 15, 1972), p. 21.

The article examines the giant \$2.4 billion food conglomerate General Foods' retreat from the fast foods industry. The corporation announced the closing of all of its 70 Rix Systems Inc. hot roast beef restaurants and the closing of at least 100 of its 1,200 Burger Chef units.

Reasons given for failure were the inability to attract customers into Rix stores and the loss of key top management personnel in both Rix and Burger Chef divisions. Adding to General Foods' woes was its discovery that long term lease commitments are debts, especially if the store fails. Pre-tax losses for General Foods in its fast food ventures totaled \$83 million, or nearly one dollar per share after taxes.

44. Anon. "Rix, Burger Chef failures leave GF with a Bad Taste." Advertising Age, 43 (February 21, 1972), p. 130.

Difficulties in General Foods fast food outlets have resulted in the closing of all 70 of the Rix Roast Beef restaurants and over 100 Burger Chef units. GF acquired Burger Chef in 1968 at which time there were 700 units, 20 percent of which were company owned. By 1971 there were 1,200 units and 34 percent were company owned. Despite a "new strong management team" installed by GF, a \$47 million net loss write off in the third quarter was found inevitable.

General Foods' difficulties in the fast food industry has been attributed to inexperience in the field, and the loss of key executives in the Rix and Burger Chef systems.

45. Anon. "Well Done!" Forbes (June 1, 1973), pp. 32-34.

The article deals with a recent situation in which Dunkin Donuts, (\$27 million in sales) the franchise food outfit, fired its certified public accountant, Price Waterhouse, a prestigious "Big Eight" CPA firm. Price Waterhouse had insisted that Dunkin Donuts adopt a more conservative accounting procedure for interest on short term notes. Upon opening a new shop, Dunkin Donuts generally borrowed money to cover all construction and equipment expenses usually in the form of a seven-year note. Interest on the note was divided equally over seven years, rather than treated as a traditional mortgage (i.e. initial high

interest payments declining over the life of the mortgage). This accounting policy inflated reported earnings 4 percent in 1970, 9 percent in 1971, and 11 percent in 1972. As Dunkin Donuts is in the midst of rapid expansion, the inflation of reported earnings would increase at even a greater rate. Dunkin Donuts made the suggested change in accounting practice and then fired Price Waterhouse.

The Securities and Exchange Commission now requires the filing of Form K-8 when a corporation changes auditors. The corporation must report the change and file a statement listing any material differences over accounting policy that had occurred in the preceding 18 months and whether these disagreements were resolved to the auditor's satisfaction. The ex-auditor then must file its own affidavit stating whether or not it agrees with the company's version of the dispute. Thus disputes between corporations and auditors are now public, offering some modicum of protection to the investor.

46. Anon. "Colonel Sanders Spreads His Wings." Business Week, (January 24, 1970), pp. 47-48.

Kentucky Fried Chicken is attempting to scale the walls of that traditional custom of fish 'n' chips--Great Britain. Colonel Sanders Kentucky Fried Chicken has 14 shops in Great Britain, most of them located in London. The British operation is operated through a franchise agreement with two Britishers, Brian Balachin and Keith Boorman. Plans call for the opening of 100 additional outlets throughout the United Kingdom.

47. Anon. "General Mills Plans Brussels Restaurant." Advertising Age, 40 (September 22, 1969), p. 8

General Foods plans to open a fast food restaurant in Brussels this month in a joint venture with Belhaize, Belgium's largest retail food chain. The restaurant will have a limited menu featuring roast beef sandwiches and will have sit down and carry out service. This unit is the first to be opened under an agreement with Performance Systems, Inc. giving General Mills exclusive franchise rights to develop Minnie Pearl chicken and roast beef concepts in Europe and the British Isles. An additional fast food restaurant concept is being tested by a General Mills English subsidiary which opened Smithy's, a restaurant featuring carry out chicken and chips located in London.

48. Anon. "Will Big Mac Meet Its Match in the Land of the Rising Sun?" Forbes, (May 15, 1973), pp. 118-130.

The reputed fast food invasion of Japan may in fact be a route of the American corporate invaders. The Japanese market would seem ideal for the fast food franchisers--100 million people who spent over \$10 billion in 1972 in more than 300,000 restaurants, mostly "mom and pop" operations. Corporations lured by this market include General Foods Burger Chef, McDonald's, Dunkin Donuts, United Brands A & W, International Multifoods' Mister Donut, International Dairy Queen, Pizza Hut, and Britain's Wimpy Ltd. Mister Donut, Dunkin Donuts, A & W, and Wimpy have simply licensed their systems to Japanese companies working on a straight

royalty basis. Burger Chef attempted to go it alone with disastrous results. Most other corporations have wisely affiliated themselves with Japanese trading companies.

Problems confronting American fast food corporations in Japan are uniquely different from those encountered in the U.S. McDonald's has had to deal with blatant imitation. One local hamburger chain, Lotteria, builds its outlets to look identical to McDonald's with the exception of name and colors. Shortages of skilled manpower and qualified franchisees have forced American companies to delay outlet openings and to place increasing emphasis on company owned outlets. Severe beef shortages due to government import quotas and government protection of domestic beef raisers make providing outlets with the required food in the necessary quantities a significant problem.

Furthermore, finding proper locations for outlets poses a significant problem. Real estate is at a premium in Japan and successful outlet locations must be located in downtown shopping districts. Purchase prices of land is prohibitive and rental rates are being driven up by competition among fast food companies. Expansion plans are seriously behind schedule.

E. Some Views of the Future

49. Jay L. Doty. "Outlook for the Restaurant Industry." Cornell Hotel and Restaurant Association Quarterly, (May, 1971), pp. 21-22.

According to Doty, sales in the restaurant business have risen at an average annual rate of 6.5 percent since 1965 as compared to 6 percent for expenditures at retail food stores. Luxury food service accounts for 20 percent of the food service industry's dollar sales with 91 percent of all establishments in this category independently owned--indicating the viability of this concept. Eighty-two percent of all restaurants are located in downtown areas while the major population shift has been to the suburbs. Difficulty commuting back to the city at night, fear of crime, and high prices have forced many restaurants to shift their emphasis to the lunch-hour customer. Rising prices, shortages of skilled labor, low productivity, and the inability to utilize saving devices have placed the service intensive restaurant in financial straits.

The fast food franchise sector of the food service industry has experienced tremendous growth with more than 40,000 franchise outlets in 1969 accounting for \$5 billion in sales. However, the fast food franchise sector also has been having difficulties. Among the causes are (1) the exploitation of the franchise concept by promoters long on marketing expertise but short on food service experience; (2) administrative and financial know how; (3) the acceptance of unqualified recruits in attempt to boost franchise sales and (4) the substitution of franchising for management talent. In the scramble of franchise expansion there has been much inept choice of sites. The neglect by the parent corporation of established franchisees has led to franchisee revolts and the withholding of royalties. Further, questionable financial practices and accounting systems have misled investors about the actual financial position of franchising systems.

With a tightening market and government regulation, reform in the fast food franchise sector can be expected. The author predicts that the current 80 percent - 20 percent division in the food service industry between fast food outlets and luxury establishments will continue to widen. Fast food establishments can be expected to make greater inroads into the retail food market.

50. Edward J. Smith. "The Quiet Revolution." Cornell Hotel and Restaurant Administration Quarterly, (May, 1962), pp. 7-13.

The rapid revolution in the food service industry is, like an iceberg, most powerfully felt beyond the eyes of the customer--in the kitchen and on the managerial levels. Changes in the restaurant industry are happening for numerous reasons; large restaurant companies, which are increasing in number and taking a growing percentage of the market, are in the best position to take advantage of these changes as they have better resources and more capital available.

The author draws parallels between the evolution of the grocery store and the restaurant industry. The grocery store has balanced high overhead and payroll costs by expanding sales volume, reducing customer services, and utilizing collective purchasing. The restaurant industry has only begun the fight to keep payroll and food costs down. Frozen prepared foods are one weapon several companies are trying in this battle. In John R. Thompson's experimental cafeteria, 75 percent of all sauces, entrees, gravies, and desserts are prepared in the company's frozen food plant. Customer reaction has been favorable, but food cost reduction can be ascertained only after the system is incorporated on a larger scale.

51. Roslyn Willetts. "Trends in Food Service." Food Technology, (May, 1973), pp. 99, 102

The two major trends in our society--(1) an increase in mechanical and electronic control, numbers-oriented record keeping and report filing, and (2) an increased awareness of individuality and ecology and a desire for organic food and informal living arrangements--will affect food service in the future. Work organization will increasingly offer workers greater responsibility and flexibility, and this will result in increased productivity and satisfaction. Computers will do routine work, particularly in the fields of food distribution and planning cyclical menus. The greater emphasis on ecology will occasion more trash recycling and air pollution prevention arrangements. Attention to more individualized nutrition and less organized eating patterns will result in more individual choices of, for example, raw or lightly cooked foods. Preparation of foods will be simplified, and new cooking methods and vessels will appear. Preparation in large-scale operations make optimum use of labor, resource and equipment. Low priced microwave ovens will revolutionize institutional feeding. And glorified self-service should increase. Portable buffet equipment will allow for varying the food or theme as will the change to many small dining rooms. Behavioral research and manipulation will open many possibilities, and as "consumers" of these new techniques, the

public must stay ahead of the manipulators.

52. Author C. Avery. "The Shape of Food Service to Come." Institution/Volume Feeding, 70 (May 1, 1972), pp. 83-95.

The author sketches the shape of the food service industry in the year 1986. The food processing industry will be completely automated. One individual will be capable of running a 10,000-meal-a-day commissary. Computer controlled, automated equipment will run the food processing operation from store room to clean up as well as take care of inventory control and the reordering process. In addition, the computer will handle all records, write all necessary business reports (including the annual report), forecast requirements, and perform all cost accounting duties.

The restaurant of 1986 will be completely automated. Customers will dine in a computer manipulated environment of aromatic and visual stimuli. They will stand before lighted menus picturing various entrees and punch out selections at order stations. Within 2 1/2 minutes they will be served the meal via conveyor belt running within the wall and stopping at the proper table. Dish bussing commences upon the customer's arising from his seat. Dirty dishes move onto a conveyor belt within an adjacent wall. The dishwashing process is completely automated. A 200-seat restaurant will require four employees and a manager. Avery notes that much of the technology of this futuristic design for 1986 is currently available and ready for implementation.

53. Alfred N. Califano and Allen Weiss. "The Turbulent Food Service Industry." Management Advisor, (July-August, 1972), pp. 38-43.

The food service industry has changed tremendously since mid-century. The industry has a tremendous impact on the economy as it buys almost 20 percent of all the food produced in the United States and accounts for purchases of over \$700 million of equipment annually. In turn, the industry is heavily influenced by the state of the economy and changing life-styles. It is presently experiencing a profit squeeze caused by inflationary pressures and aggravated by consumer resistance to rising prices, rising labor costs, and painfully high restaurant rents.

The food service industry is turning to convenience foods as the principal solution to the profit squeeze. These foods require less skilled labor and less kitchen space. The systems approach answers the need for the coordination of all the required functions.

54. Mary Bralove. "Most People Have No Taste; It's Been Lost in the Process." The Wall Street Journal, (April 30, 1974), p. 1.

Food manufacturers have discovered that consumers have become so accustomed to mass produced, artificially flavored foods that sometimes real, natural flavors are found to be objectionable. Consequently, flavor designers are moving away from a fresh flavor bias. This raises the distinct possibility that food analogs and other manufactured foods may become increasingly acceptable.

55. Edward L. Perkins and William S. Penn, Jr. "Special Food and Equipment for the Food Service Industry." Food Technology, 24 (September, 1970), p. 970.

The food service industry is experiencing an industrial revolution, substituting production line labor for craft labor and substituting capital for labor. Extensive change is occurring on both the operational and structural levels. Structural change is primarily consolidation, both horizontal, and vertical, with an emphasis on the "systems approach." The major focus of the industry will be on convenience foods. According to a recent survey by Volume Feeding Management, up to 50 percent of the units are already using certain types of convenience foods and the outlook for the future is a steady increase. Most outlets combine convenience and conventional foods in some sort of "mixed system." Equipment in the next few years will probably see the advent of full-line suppliers, the present lack of which is hampering innovation and systems development. In their conclusion, the authors single out convenience foods, custommade products, and multiple packaging options as major forces in the future. They also see food technologists as playing a vital role in completing the food service revolution.

56. Carol Walek. "Monorail Meals." Food Technology, (September, 1972) pp. 30-34.

St. Elizabeth Community Health Center in Lincoln, Nebraska, has changed the traditional health-care feeding for its 208-bed unit by instituting Monorail (an automated cart transport system), an assembly-line-type kitchen, and galleys on each floor equipped with microwave ovens, roll-in refrigerators, and other necessary appliances. In the main kitchen, food is prepared, portioned, wrapped, and quick frozen. On the day of service, appetizers, salads, and desserts are prepared. All items are assembled on trays and transported to floor galleys where the final preparations are made. Utensils and carts are cleaned and sterilized before re-entering the kitchen.

This system provides a wide range of selections even for patients on restricted diets. It takes only 45 minutes to prepare the meals for the patients on an entire floor. And food costs have remained as low as in the more traditional systems--approximately 50¢ per meal. The quality and variety of food available at any hour of the day is seen as an improvement by both patients and staff.

57. Betty Ronan. "A 'Cooking Street'--Is It a Possible Food Preparation System?" Journal of the American Dietetic Association, 63 (October, 1973), pp. 417 - 418.

One German equipment company has developed a "cooking street," a line-up of high volume durable cooking equipment which is totally automatic except for the loading of bulk raw food. The arrangement of the equipment (deep-fat fryer, steamer, water cooker, and broiler) is variable, and it is available in two sizes. This system offers efficient use of kitchen personnel--two workers can man five pieces of equipment and in one institution 5,000 guests were served by a staff of

nineteen. The system may be used to prepare food for immediate service, in which case it is automatically transferred to heated containers and conveyed to the distribution point; or it may prepare food for freezing, to be reheated later, often at a "satellite location." This seems to be the trend in Germany. After cooking, the food is automatically weighed into steamtable pans, covered, quick-frozen, and stored.

II

FOOD PROCESSING AND PREPARATION EQUIPMENT
AS IT SHAPES THE FUTURE
OF FOOD SERVICE

by

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FOOD PROCESSING AND PREPARATION EQUIPMENT
AS IT SHAPES THE FUTURE
OF FOOD SERVICE

Introduction

The operation of food processing and preparation equipment is primarily governed by the rates at which heat and mass can be transferred to or from food. Therefore, it is appropriate to include with this paper a brief but technical discussion of the basic modes of heat transfer-conduction, convection, and radiation. Since the balance of the paper is much less technical, however, we have chosen to place this discussion of heat transfer modes in an Appendix. In addition, we have also included a Glossary of terms normally associated with heat transfer and used in this paper.

We begin with a discussion of past, present, and future research activities in heat transfer, placing particular emphasis on areas that are of specific importance in food processing and preparation. Then we review the equipment already available. In our conclusion, we predict the impact of engineering technology on future trends in food preparation and processing equipment with particular reference to those areas that require additional research.

Research in Heat Transfer

During the past 30 years, an extensive research effort has been undertaken by universities, industries, and government laboratories to further an understanding of the basic phenomena governing nearly all aspects of fluid mechanics, and heat and mass transfer. A summary paper and a projection of future trends has been presented by Sabersky (41). A great number of these research activities focused on problems associated with the aerospace and nuclear power industries where a precise knowledge of these phenomena is essential. Topics of particular interest to the food industry include

1. Property Evaluation. Standardized tests have been developed for the determination of the thermal conductivity, thermal diffusivity, and specific heat of various food substances, and the values of these properties have been published in the technical literature. Extensive work has also been devoted to a determination of the radiation properties of surfaces. In fact, there is considerable interest at present in the determination of the dielectric properties of foods because of the increasing use of micro-wave heating.

2. Prediction Techniques for Rates of Heat Transfer. The accuracy of the prediction of the ratio of heat transfer for complex as well as simple situations has greatly increased in the past few years. Part of this improvement can be attributed directly to

the availability of more accurate thermal property values, discussed in Item 1 above. Significant improvements have also been made in our ability to predict the values of the convective film coefficients for complicated flow systems, but more research is still needed in both the areas of forced and natural convection turbulent flows. Although more sophisticated analytical techniques have been developed, the major contributions can be attributed to the development of numerical techniques for the solution of heat transfer problems and the use of the digital computer in performing the calculations. The application of these techniques for conduction heat transfer are well documented in the technical literature, and they are currently being developed and refined for application in the solution of fluid flow and convective heat transfer problems. These numerical techniques thus enable heat transfer rates to be determined in complex geometries and with variable thermodynamic properties, conditions which are often encountered in the commercial food industries.

3. Simulation of Processing Equipment. In food processing equipment, several different modes of heat transfer occur simultaneously, many times when several different fluids are present. Examples of such units are heat exchangers, evaporators and condensers. To optimize the design of these units, numerical simulation procedures have been established that help determine the equipment characteristics at off-design operating conditions and its response to transient changes in the operating parameters.

4. Instrumentation. Items 1-3 have dealt mainly with the prediction of rates of heat transfer and the performance of heat transfer

equipment. An evaluation of accuracies of these predictions can be obtained only through a comparison with experimental results. The development of devices for measuring temperature, fluid velocities, and heat flow as well as the thermal properties noted in Item 1 has been rapid. The aerospace and nuclear industries have been particularly concerned with securing accurate remote sensing devices, as well as data acquisition and analysis systems. Stable electronic packages that process signals from thermo-couples and thermistors for temperature measurement, and hot film, hot wires, and laser Doppler anemometers for velocity measurements have assisted greatly in the design of experimental studies.

Basic research into the fundamentals of heat transfer has resulted in the introduction of many new pieces of equipment. The microwave oven and the heat pipe are just two examples of equipment that will make a considerable impact on the food preparation industry in the future.

Microwave ovens have been commercially available for several years. Their energy is generated by a magnetron tube and directed into the oven's heating cavities. The rapid reversal of the high frequency field causes electrically polarized molecules in the food to oscillate, resulting in molecular friction and heating. The key to effective design and operation of microwave oven is to exclude all materials that tend to absorb microwave energy from the oven cavity, other than the food to be heated. The temperature distribution in the food will not be uniform because of local variation in the dielectric properties; thus local hot spots will occur in the food. These hot spots can result in irreversible

damage to the food at these location. (Microwave ovens are discussed in more detail on page 93.)

The basic heat pipe is a closed container which contains a capillary wick structure and a small amount of vaporizable fluid. A sketch of a heat pipe unit is shown in Figure 1. The unit consists of a heating section where the fluid is vaporized, a cooling section where the fluid is condensed, and a wick structure which transports the fluid from the cooling end to the heating end. Extremely high rates of heat transfer are obtainable with the heat pipe, and the surfaces of the units remain at an essentially uniform temperature. The value of the temperature is controlled by the selection of the fluid and its operating pressure.

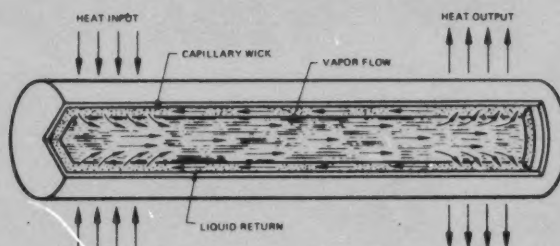


Figure 1

Basic Heat Pipe Configuration (21)

Food Processing and Preparation Equipment

A discussion of equipment currently available in the food processing and preparation industry follows here. We also intend to mention the equipment needed for the storing and thawing of food.

Freezers and Refrigerators

Freezing and refrigerating food products have been predominant means of food preservation and storage for many years now. With the advent of central commissaries and food satelliting systems, however, freezing and refrigeration are being applied more and more in conjunction with the food preparation industry. Refrigeration and the various types of freezing can be classified into two categories: "initial" and "holding." Initial freezing takes food from its fresh or prepared state to its frozen state, after which it is held in freezers. The various methods used to accomplish this process are discussed below, along with the advantages and disadvantages inherent in each freezing method.

Plate freezing. This method of freezing has been commonly used for many years with few changes. The refrigeration equipment is composed of an evaporator, where heat is transferred to the refrigerant; a compressor; a condenser, where the heat is ejected to the surroundings; and an expansion valve. The evaporator is located in the walls of the refrigeration chamber and has the lowest temperature in the cycle. Plate freezing is a very slow method of freezing because heat must be

conducted outward through the product, then transferred by convection through the surrounding air to the refrigerant-carrying coils located within the chamber walls. For this reason, its popularity as a means of initial freezing is decreasing in favor of more modern, rapid methods. Plate freezing is still widely used, however, for holding frozen foods because it is simple and relatively inexpensive.

Although there have been no dramatic changes in the plate freezing system, the units on the market now are much more sophisticated than their predecessors. New refrigerants, better insulation, and more efficient evaporator and compressor designs have reduced the amount of room required in a cabinet for the equipment thereby allowing more freezer space for a given outer envelope volume.

When using these units for holding, one must take precautions to insure that the equipment is not left without power for a significant period. Many of the new units are equipped with high-temperature sensors, telephone dialing units, and auxiliary power supplies that can be switched automatically or manually to provide electricity for the freezer.

Blast freezing. Blast freezing, along with other systems yet to be described, has been designed to accomplish initial freezing. This method utilizes a mechanical system with enclosed refrigerant to provide low-temperature air, generally -35 F, to the freezing chamber at a high velocity in order to speed the transfer of heat from the product. To provide even temperature distribution and maximum exposure of the product, blast freezing utilizes a series of baffles.

Some of the advantages of blast freezing follow here:

1. High density products with a large physical plane geometry can be frozen in a short time.
2. Packages of various sizes can be processed, even when intermixed.
3. The temperature of the air stream can be maintained at -35 F so that the introduction of warm products will not raise the temperature of the chamber.
4. After the initial investment for equipment and installation, operating costs are nearly constant, except for the cost of electricity. (The higher the volume processed, the lower the unit cost for freezing.)

There are some disadvantages to this method, however, and they follow:

1. A large amount of physical space is required for blast freezing installation.
2. Its large number of relays, interconnects, and other electrical systems can lower reliability. If one component malfunctions, the entire system fails.
3. Leaking packages can cause a mechanical malfunction. Careful control of the production line must be maintained to eliminate "leakers."
4. Cleaning is difficult. USDA inspectors, constantly on duty in major food plants, may insist at any time that the freezer and conveyor be cleaned. The freezer cannot be shut down during operation without the possibility of food spoilage, so cleaning is an expensive process involving indirect labor, special

anti-freeze cleaning solvents, and the possibility of inconvenience and waste.

Cryogenic freezing. This system freezes a food product by direct contact with a liquefied gas, usually nitrogen. The liquid nitrogen is stored at a temperature below its boiling point of -320 F and is vaporized by heat absorbed from the food. The rate of heat transfer is greater than in a blast freezer because the transfer medium is a liquid rather than a gas and a change of phase occurs.

In an operating unit, which is usually a continuous, conveyor-fed device, the product passes through a chilling zone into the freezing zone where it is sprayed with liquid nitrogen. It then passes through an equilibration zone, to allow temperatures within the product to equalize, before leaving the unit. The chilling zone is created by circulating the cold, vaporized nitrogen through that area of the chamber.

The use of liquid nitrogen as an expendable refrigerant has become more practical since its cost has decreased greatly. Consequently the demand for liquid oxygen has increased tremendously in the past decade: the space program uses it as a rocket propellant. The steel industry has developed new processes requiring pure oxygen. That liquid oxygen is obtained from air, yielding as a by-product about three times as much liquid nitrogen.

These are the advantages of cryogenic freezing:

1. Little space is required for its installation as compared to a blast freezer.
2. Disassembly and cleaning requires relatively little effort.

3. Dehydration of the product during freezing is minimal--less than 0.44% of prefrozen weight.

Its disadvantages follow:

1. Freezing costs vary according to input rate, product density, and product geometry. Costs are lowest with a high input of products of a single size and shape.
2. Water vapor in the air entering with the product causes frost build-up which hinders the operation of bearings, shafts, and conveyors.
3. Certain products and packaging materials are not compatible with cryogenic freezing. Food packaged in plastic pouches, for instance, cannot be frozen by this method because the plastic cannot withstand the -320 F temperature. Material in pans must have the cold penetrate the pan before freezing begins. Thus, if possible, the product should be frozen before being packaged. Some products can be overfrozen and become brittle, and since many foods can be acceptably frozen at -5 F or -30 F, a lower freezing temperature is wasted.
4. After the freezer is cleaned, it must be dried thoroughly before using. (But forced-air units may be installed to speed the drying.)
5. If production stops while the freezer is operating, some liquid nitrogen is constantly expended, which costs money. If the freezer is shut down, restarting requires considerable time and a good deal of liquid nitrogen to chill the unit.

Immersion freezing. Previously immersion freezing was accomplished

by immersing the product in a mechanically refrigerated brine solution. Food was protected from the brine by plastic wrapping or a metal container. The newer equipment, however, uses liquid Freon as the refrigerant and operates in a temperature range of -22 F to -35 F. Because the product comes directly into contact with the cold liquid refrigerant, similar to cryogenic freezing, the rate of heat transfer from the product is greater than in plate or blast freezing.

Extensive studies have been conducted to investigate the safety of allowing Freon to come into contact with food, and the method has received approval from health authorities.

Here are the advantages of immersion freezing:

1. Little refrigerant is expended as compared with liquid nitrogen. The higher vaporization temperature of Freon allows for economical condensation and reuse. In various plants now operating, more than 99% of the Freon vaporized during freezing is reclaimed.
2. Moisture is kept out of the freezing chamber by using the "heavy" Freon vapors to displace incoming air. Any water vapor which does enter is suspended in the Freon and removed when it is recycled.
3. Because the freezer operates in the -35 F temperature range, there are no adverse effects on packaging materials.
4. Based on actual operating figures, freezing costs are between one-fourth and one-third those for liquid nitrogen freezing.

The disadvantages of the Freon freezing system follow:

1. Initial investment for the unit is high, approximately twice

the cost of the liquid nitrogen system.

2. This method is still being tested for a wide range of food products. Therefore, not all applications and shortcomings of the system are known.

Individual quick freezing (IQF). IQF is not a different equipment system, but rather a new approach to freezing certain products. Items of small individual size, like peas, strawberries, and shrimp, are loaded in loose form. As they pass through the freezer, they are frozen individually, rather than in a large block or package. Blast, cryogenic, or immersion freezing can all be used for this process. Because of the small size of the product, each individual piece freezes rapidly. Faster freezing results causes smaller ice crystals to form within the product, thus less cellular damage occurs than the large crystals, formed during slow freezing, cause. This means that product texture improves and drip loss during thawing lessens. Studies have shown that blast freezing gives superior results to plate freezing, with cryogenic and immersion freezing being better yet (13).

Thawing Equipment

Because large quantities of many foods can be preserved for long periods, freezing has become one of the most widely used packaging methods of our time. But all too often, considerations of how to thaw frozen food have been ignored, negating any gains from the improved preservation freezing provides. The old method of leaving frozen foods on a counter top until they thaw is no longer acceptable, either from the standpoint of quality retention or sanitation. This

is particularly true of the larger packages in which food is now being frozen: by the time the material in the center of the package has thawed, the outside has been at or near room temperature for a considerable time. To overcome this problem, various types of units are available to thaw food quickly and safely. These include conventional tempering cabinets and newer microwave and vacuum thawing systems.

Conventional tempering cabinets. Conventional thawing utilizes standard refrigerators or coolers to raise the temperature of frozen products for subsequent processing or preparation. Although this method keeps the food safely refrigerated, it can be slow and may require as long as three days for complete thawing, depending on the product type and size. It also requires considerable space devoted to chilled storage. Several manufacturers have developed refrigerators that serve the dual purpose of standard refrigeration and thawing (20). By adding such accessories as auxiliary heaters and fans to increase air movement, thawing time can be reduced to between eight and twelve hours while a safe average refrigerator temperature of around 40 or 45 F, which keeps food below 40 F, is maintained.

Microwave thawing systems. This system uses microwave power to raise the temperature of large blocks of a frozen product. Microwaves are especially effective because they penetrate the interior of the package, rather than relying on heat conduction from the surface to the center of the block. This method is generally applied in a continuous type system where the degree of thawing can be controlled by conveyor speed or the microwave power level. One manufacturer claims that

60-pound blocks of beef can be tempered from -10 F to 27 F in approximately five minutes with this system (37).

Vacuum thawing systems. One manufacturer has developed a unit that uses heat released by condensing steam to warm a frozen product (2). Because of the low pressure within the chamber, the steam remains at a temperature of 68 F to 77 F, instead of the 212 F boiling point. This method thaws food quicker than conventional means and may be suitable for tempering food for immediate use. But prolonged exposure to the temperatures it uses could cause food quality degradation.

Both the microwave and vacuum systems are faster than the conventional means, thus they are more convenient and reduce the large space otherwise required for tempering rooms. Application of microwaves is faster than vacuum thawing and results in a more uniform temperature distribution throughout the product. This is especially desirable because certain processes, like slicing, dicing, and grinding, require the food to be at a specific temperature for the best results.

Ovens

Ovens are the equipment most often used to heat food products, both in the food service industry and in home cooking. They are used primarily to cook such items as meats, casseroles, and bakery products, and they are also used to reconstitute modern convenience foods. For years, the only ovens in widespread use were the electrically heated or gas-fired free-convection ovens. However, the demand for reduced processing time and higher volume production has forced operators to

consider alternative heating methods. Two of the most promising new pieces of equipment available are forced-convection oven and the microwave oven.

Forced convection ovens. Forced-convection ovens, referred to usually as "convection ovens," are really only a slight modification of the standard free-convection ovens. A recirculation loop is added wherein a fan forces reheated air through the cooking chamber at a high velocity. The increased velocity reduces the thickness of the air film surrounding the product to be cooked and allows more heat to be transferred to the product's surface since its convective heat transfer coefficient is increased. As the air circulates, it absorbs moisture from the product, dehydrating it somewhat. But because the air is recirculated rather than being exhausted, it soon becomes saturated and will not absorb any more moisture.

The higher rate of heat transfer decreases cooking time as much as 50 percent in some instances, and allows cooking at lower temperatures, which reduces drip loss, scorching, and fuel consumption. These large reductions in cooking time occur only if the block of food being heated is not too large. For a thick block, conduction of heat through the product becomes the limiting factor, not the rate at which heat is transferred to the surface. In this instance, heating time will usually be reduced about 10 percent.

The major shortcoming of convection ovens seems to be its uneven heat distribution. Because of varying oven loads and possible tray configurations, temperatures can vary as much as ± 10 percent throughout the cabinet, despite the use of vents and baffles to combat this problem. One manufacturer claims an ability to control the temperature

FAN ROTATION INSIDE OF OVEN COMPARTMENT - LOOKING TOWARD FAN

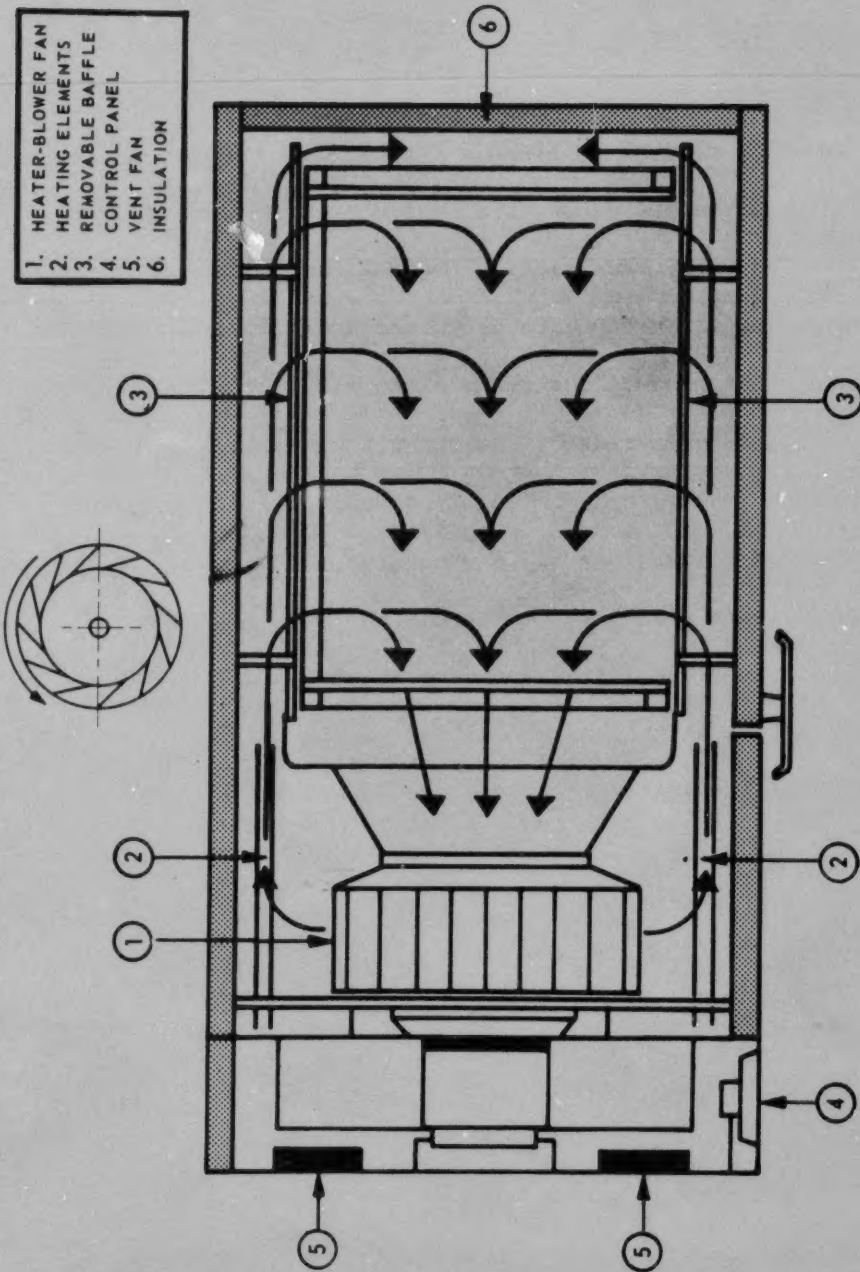


Figure 2

"Crown X" Forced Convection Oven (7)

to within ± 5 F in his unit. He does this by blowing air first from one side, then the other, rather than constantly from the back as is done in most American-made units. European manufacturers have been using the side-fed system for years, allowing them to gang multiple ovens side by side without the installation of additional heater/blower units (51).

Forced-convection ovens are gaining rapidly in popularity. They are being installed in most new operations and are replacing free-convection ovens in many existing facilities. (Figure 2 depicts a typical forced-convection oven.)

Microwave ovens. When microwave ovens were first introduced, they were hailed as the future mainstay of the food service industry. They haven't yet fulfilled this prediction, but they have been increasing rapidly in popularity during recent years and will probably continue to show increased use in the future as more of their problems are overcome.

Microwave ovens transform electrical energy into microwaves by means of electronic equipment. The microwave frequencies which have been found most suitable for cooking are 915 and 2450 megacycles. The microwaves penetrate the product and are absorbed, releasing their energy to the molecules of food and quickly raising the product's temperature. Because the energy is deposited throughout the product, rather than just on the surface of the food and because the heat need not be conducted to the interior, cooking time is reduced substantially. Microwave cooking can be applied to batch-type as well as continuous operations.

A distinctive characteristic of microwave ovens is their use of energy. In other ovens, the product, the air within the cooking chamber, and the walls of the chamber all absorb heat. In a microwave unit, all the energy heats the food. Air passes microwaves without absorbing them and metal walls reflect microwaves without absorbing them. Unfortunately, the electronic systems that convert electricity into microwaves are only 30 to 50 percent efficient in the sizes and power levels now in use. Most units now available require about 3 kw input power and have an output of approximately 1 kw. But one manufacturer of microwave power modules has developed a high-power unit which he advertises as 72 percent efficient (22). With an output of 425 kw, this module could be applied in operations involving extremely high volume production.

Microwave ovens aren't in the widespread use initially predicted for them because of problems, some real and some only imagined, encountered during development. An understanding of these problems and what is required to overcome them is necessary in order to draw predictions about future applications.

The first shortcoming of early units was uneven heat distribution. Because of the extremely regular shape of the standard rectangular cooking chamber, standing waves caused "hot spots" within the product. Modern units use rotating fans called ("stirrers") or reflective grids to disperse the waves evenly throughout the oven cavity.

Early literature also reported the formation of undesirable chemicals as well as ions and free radicals which react to form secondary products. In these early ovens, however, spark formation and leakage of x-rays from the microwave generator were not uncommon.

Energy released by these means is sufficient to cause ozone formation or to break chemical bonds. Recent studies have shown, however, that microwaves transmit too little energy, by several orders of magnitude, to be directly responsible for any chemical changes (34). But in a localized "hot spot," chemical reactions may occur which might not be desirable at the indicated mean temperature of the product. These thermally-induced effects account for most, if not all of chemical changes observed in microwave heating.

Even when the distribution of microwaves is uniform, "hot spots" can occur due to non-homogenous or irregularly shaped products. Most biological materials are composed of layers or striations of muscle, fat, and connective tissue or, in the case of fruits and vegetables, flesh, woody pulp, and seeds. Each of these has a different dielectric property. This variation can cause localized heating in a material which makes up an otherwise insignificant portion of the total product.

Moreover, particular care must be taken when heating products that have been previously frozen since microwaves affect water at a much higher rate than ice. To counteract this problem, a system of pulsed microwave application has been devised. Energy is applied for a short time, then the product is rested to allow heat to conduct evenly throughout the food. This adjustment not only allows heat to dissipate from any high-temperature areas, but also allows conduction inward, where the material is less affected by the microwaves directly.

Because microwaves deposit their energy evenly throughout the product, the outer surface receives the same treatment as the remainder of the food. In other words, there are no surface effects like

charring, browning, or caramelization. Consumers have come to expect surface treatments on many of their foods, so many products cooked by microwaves are not completely acceptable even though they are thoroughly cooked. For this reason, other means of cooking are often used in conjunction with microwaves. Steaks and chops may be seared on a grill prior to microwave cooking while bread or cakes are cooked at high temperatures for a short time in another type of oven, then finished by microwave power. White bread and rolls have a surface texture and color resembling brown-and-serve rolls, with no surface browning or glaze, after microwave baking. However, satisfactory results have been obtained with dark breads, such as whole wheat and rye, and dark colored cookies using microwave processing exclusively (29).

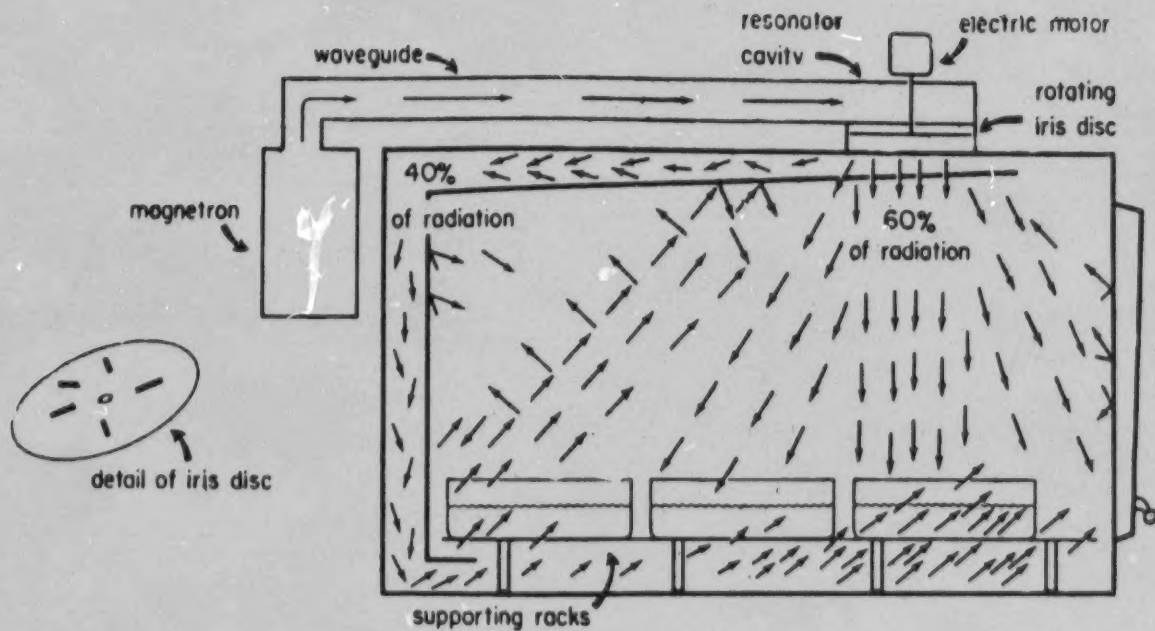
Another problem when cooking with microwaves occurs with the use of metal pans. Microwaves are reflected by the metal, thus heat does not penetrate through the bottom or sides of the pan. Most of the ovens in production today have a circuit which will shut off power to the oven if there is excessive microwave reflection within the cooking cavity. New temperature-resistant plastics that pass microwaves have been developed and offer great promise of a solution to the reflection problem. The ability of metal foils to block microwaves has been utilized to allow selective heating of pre-plated food. Perforations in the metallic shield allow varying degrees of microwave penetration; certain items are heated, some thawed, and others remain frozen, as desired. Metal shielding on the sides of flat baking pans prevents the "edging effect," overbaking of edges and corners due to microwave

application from top, bottom, and sides simultaneously. (A typical microwave oven is schematically depicted in Figure 3.)

Combination ovens. Combining another means of cooking with microwaves takes advantage of rapid, uniform microwave heating while compensating for the shortcomings of a pure microwave system. Supplementary processes like grilling, frying, roasting, or baking can be applied before or after microwave processing, as discussed previously. In fact, units are now available that combine heating methods in one place of dual-purpose equipment.

Excellent cooking results have been obtained with microwave-convection ovens in which the two processes are applied simultaneously or separately (23). This test also studied the feasibility of using special aluminum foil pans as containers during cooking. The pans were modifications of standard aluminum foil containers in which food is commonly packaged. To allow microwave penetration from the top, the lids had a pop-out window which, when removed, exposed a see-through oven-service film through which microwaves could pass. The underside of the pans were black-coated to improve heat transfer to the product through the bottom of the container. The lid also served to retain moisture in the container, raising the interior temperature and minimizing food dehydration.

Several microwave units for domestic use have been manufactured with resistance heating elements at the top and bottom of the oven to provide radiant heat. The resistance elements also serve as microwave antennas to transmit energy produced by the microwave power modules. The addition of a simple blower would provide forced-convection heat-



CROSS-SECTION VIEW THROUGH ONE END
of microwave oven showing wave pattern
through three water loads at one instant

Figure 3

A Microwave Oven (15)

ing and could further improve heat transfer to the product being cooked.

The use of a steam atmosphere in conjunction with other heating means like radiation or convection has been applied in several units. The additional moisture helps prevent undue product desiccation and gives a surface glaze to certain baked goods. A steam environment is particularly desirable in certain microwave applications like vegetable blanching. Microwaves heat the interior, but evaporation cools the surface of the product. Moisture must be maintained in the environment to heat and blanch the surface.

One manufacturer makes use of refrigerated air in infrared and combination infrared-convection ovens (28). Temperatures within the chamber can be as high as 600 F to 850 F, easily scorching the surface of the product. The refrigerated air reduces the scorching while it allows maximum penetration of the infrared rays. But expending energy to heat and cool a product simultaneously would seem to be questionable efficiency, particularly if equivalent results can be obtained by other means.

Other oven types. Other types of ovens, like the infrared and quartz plate ovens, are not used as widely as those already mentioned, nor are they increasing in popularity as quickly as convection and microwave ovens. Since there is little information on them in current literature, we offer no comments on their specific characteristics and their practical food service applications.

One method for reconstituting prepared foods that deserves mention is the Integral Heat System (45). This system seems to be competitive

with small microwave kitchenettes used in hospital wards (25).

Specially designed dishes in which food is cooked and served are made in two parts: the outside shell is a high-quality polymer, while the inner dish is porcelain ceramic with carbon resistor material fused to the underside. Electricity is conducted from the rails of the holding cabinet through electrodes in the outer shell to the resistor. There it is converted to heat and conducted to the food. No heat is wasted through the heating of the air in the oven cavity or the walls of the cabinet.

Standard 10- to 12-oz. hospital meals can be reconstituted from the frozen state in 18 to 20 minutes, compared to the 35 to 40 minutes required by convection ovens. Already thawed meals can be heated in approximately half the time of frozen foods. Food can be held in its heated state if convenient for the recipient, making this system ideal for hospitals and in-flight airline food service.

Fat Fryers

Deep fat fryers cook food by immersing it in liquid cooking fat which is heated through some type of heat exchanger. The source of heat can be either electricity or gas. The hot fat has a higher heat capacity than air and provides a high convective film coefficient. This characteristic provides a faster rate of heat transfer than a gas like air under free convection conditions.

Though the basic concept of deep fat frying has not changed over the years, refinements of the equipment provide for more convenient operation and higher quality products. Units now available have more accurate thermostats and timers built in for better process control.

Automatic basket lifts terminate cooking after a preassigned length of time to prevent overcooking. Most designs include a "cold zone," a space beneath the heating tubes which does not reach as high a temperature as the fat above the tubes that cooks the food. Food particles drop into this area of cool fat (or water in some equipment) and do not carbonize as rapidly. This reduces the rate at which the fat breaks down and becomes unsuitable for further use. In addition, to prevent fat breakdown, some systems have built-in equipment for filtering the oil. Others must use separate units designed for this purpose.

A recent development in this cooking method involves a pressurized container during cooking. At the beginning of the cycle, the vat is covered and sealed. As the food is heated, internal moisture is turned into steam which increases the pressure inside the vat. Pressure forces the fat against the product and increases the rate of heat carried into the food. The moderate convection caused by heating the fat agitates the product providing equal exposure of all surfaces to the cooking oil. Improved efficiency of heat transfer combined with sealing in the hot vapors means the oil can be used at lower temperatures. This lengthens the life of the fat and reduces fuel consumption.

Up to 75 percent of the original moisture of the product is retained during pressure frying, as opposed to approximately 50 percent retained in open vat frying. Moreover, proper frying results in as little as 4 percent fat absorption.

To show how fat frying can be used on products not generally associated with this type of cooking, a recent demonstration used cuts of U.S. choice steak. The resulting steaks were grease-free and cooked

to the specified degree of doneness. They were considered by several tasters to be almost indistinguishable from U.S. prime meat. In another test, pressure fried steaks were judged to be more tender than broiled steaks (34).

Cookers

Steam cookers operate on the principle that heat can be applied more efficiently through a moist medium than a dry medium like air. Modern steamers perform much the same functions as their predecessors, but they have been updated to meet modern standards of convenience and quality. In the past, steam was supplied to individual units from a central steam generator. If the central unit failed, all the kitchen equipment that required steam stopped. Equipment now available not only connects to steam lines, but can also operate from self-contained steam generators. These generators can use gas or electricity for steam production and operate quietly without the hammering and hissing associated with steam generation. Typical units utilizing steam heat are steam jacketed kettles, low-pressure and high-pressure steamers.

In a steam jacketed kettle, steam is introduced into a hollow shell surrounding the cooking vat. Condensation on the inner wall transfers heat from the steam through the wall to the food. The higher the pressure of the steam, the higher its temperature and the more heat it will transfer to the food. Kettles can be equipped with automatic scraper paddles to blend such items as gravies and sauces continuously during cooking. Some units have provisions for filling the jacket with cold water after cooking is completed to cool the product faster (44).

Low-pressure and high-pressure steam cookers allow steam to come in direct contact with the product to be heated. Low-pressure units operate at approximately 3 psi, providing steam at 220 F. This equipment can be used to reconstitute frozen foods if the packaging will prevent entry of steam into the package. High-pressure steamers supply steam at 15 psi and 250 F. They are widely used to heat frozen vegetables in open or perforated trays.

Due to certain shortcomings, steam cooking seems to be declining in popularity in the face of such new equipment as convection and microwave ovens. Although moist heat prevents dehydration, many items cannot be reheated this way because the moisture adversely affects product quality. Also, steam heating is slow compared to other cooking methods. And condensation resulting from hot steam coming in contact with the cooler product forms a film which resists heat transfer. Forced convection of the steam shortens reconstitution time, but not enough to make it truly competitive with other means. One user of steam equipment says that steam cooking is on its way out; microwave and convection ovens are what people are using (18).

An equipment system still under development is a heated water bath for reconstituting individual portions packaged in flexible plastic pouches. The primary requirement for this unit is a high rate of heat input into the water bath. The water must be kept at a rolling boil, even when several pouches are immersed in the bath simultaneously, because the only way to insure proper cooking is to control the length of time the product is immersed. Another necessary component of the system is a system of racks to keep the bags submerged and separate

from one another to allow free water circulation. An automatic timing and retrieval system should also be included so the operator does not lose control of the heating time for any individual pouch. If "boil-in-bag" products continue to increase in popularity, commercial units of this type may soon be available.

Broilers

Broiling is the traditional way of preparing many of our most popular foods. Units now available are electric or gas-fired, and food service operators generally prefer the gas-fired equipment. The method of heat transfer used in broilers is radiation, either from electrically heated resistance elements or heated ceramics in the case of gas equipment. Heat is transferred to the surface and is conducted inward. A characteristic of broiling is that the surface is seared and the natural juices sealed in. Some new units are constructed so that the product is cooked on both sides simultaneously.

Most commercial installations are now using infrared broilers because of the high temperatures generated and the resulting increase in the rate of heat transfer. High-volume operations are making use of continuous-type equipment which requires only unskilled labor once the temperature and belt speed have been fixed for a particular product.

Char broilers with their open flames are used primarily as specialty equipment and to provide "atmosphere."

Holding Equipment

In the past, prepared food awaiting service was held in steam

table pans to keep warm; or if the food was to remain chilled, it rested on a bed of crushed ice. Though some deterioration of product quality occurred during the holding period, this procedure remained acceptable for holding bulk pans of food, for example on a cafeteria serving line. The proceeding is not practical, however, in such applications as hospital food service or when food is transported from a central commissary to a satellite location.

To overcome this problem, holding cabinets have been developed to maintain the food at an optimum temperature. These cabinets include three basic types: insulated, heated, and refrigerated.

Insulated cabinets. Insulated cabinets have no heating or cooling equipment built in, rather they prevent the temperature of the product from changing drastically once it is loaded into the cabinet. These cabinets are particularly useful when there is no power source available for heating or cooling while the product is in transit or at the location where it is to be consumed--for example, in a "meals-on-wheels" program or the feeding of large numbers of farm workers in the field.

Heated cabinets. These cabinets contain an electrically-powered heating source and may be either insulated or uninsulated. They are capable of holding temperatures from room temperature to as high as 200 F or 250 F, though ideal serving temperatures for most foods range between 160 F and 190 F. Many of the units now available actually house two separate holding containers in one cabinet. They are separated physically and have independent thermostats so that various foods may be kept heated to different temperatures.

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Refrigerated cabinets. These cabinets resemble heated cabinets, but have self-contained cooling systems. Many are available with separate freezer sections in addition to refrigeration. Temperatures within the different sections can be adjusted within certain limits.

Heated and refrigerated cabinets are often transported in vehicles with special electrical circuits to provide power to the containers. They can also be plugged into standard outlets at their destination. Heated cabinets can be used for reconstituting pre-plated meals when food is being satellited from a central commissary to schools or hospitals, for example. All types of cabinets are designed to accept trays and pans of various standard sizes and depths.

Several manufacturers offer cabinets that can be switched from refrigeration to heating (6, 10, 13). This feature is particularly useful for reconstituting food that should be stored under refrigeration for a period of time. It also provides added versatility to high-volume operations, since it can be used in either mode, depending on the relative amounts of heated versus refrigerated food being held. It reduces the number of extra cabinets that must be maintained to compensate for variations in the type of holding method required.

Waste Disposal and Pollution Control

Recent public awareness of environmental abuses has caused American industry to re-examine its methods of waste disposal and pollution control. Food service operations have not escaped criticism and must now begin to solve those problems particular to their industry. Means of disposing of solid waste fall into three main categories:

compaction, shredding, and incineration.

Compactors. Particularly when they package the waste in plastic bags, compactors can cause the refuse to become less biodegradable. Recent studies have shown, however, that proper packaging and handling during final disposal minimize this problem (52). The biggest single advantage of compactors is that they reduce the volume of trash to be hauled away and the space required for storage between pick-ups.

Shredders. Shredders consume paper, plastic, cans, and bottles and chop them into small pieces. Like compaction, this process significantly reduces the volume of refuse. It also aids in subsequent reclamation of recyclable materials and makes non-recyclable substances more biodegradable.

Incineration. Burning refuse effectively eliminates the intermediate steps involved in other methods of disposal by destroying the waste products immediately. In many locations, however, incineration is not allowed, and where it is, strict regulations are in effect concerning emissions. Incineration is often the means of final disposal for non-recyclable materials processed by compaction and shredding.

The other ecological concern with which food service operators must contend is control of other emissions from their establishments. These can and often do include vapors from ranges, grills, and fryers, as well as from incinerators. Preliminary filtration of exhaust air from cooking areas is usually accomplished in one of two ways: The older method, still widely used, is to pass the air through a simple filter to remove grease. Formerly, the filters were used for a short time, then disposed of when they became too grease-laden to

perform efficiently. Later filters could be cleaned by a washing in a standard dishwasher and reused thereafter. Newer filters consist of a series of baffles through which exhaust air passes at high speed pulled by an exhaust fan. Grease particles are thrown out of the air stream, collected in a grease trap, and disposed of. These filters remove more grease than the older types, reducing build-up in the ductwork. And they also retain less grease in the filter itself; both characteristics reduce the chance of fire.

The other system of preliminary filtration is more sophisticated and costly, but it can pay for itself in other ways. Exhaust vapors are subjected to a high-pressure water spray which cools the air below the condensation point of grease. The grease is carried away by the water into the sewer system. Because the exhaust air has been cooled, heavy-gauge ductwork and insulation formerly required may no longer be necessary.

A water spray can also be used with baffle-type filters to wash away trapped grease. These water sprays act as a fire barrier to prevent a fire in the cooking area from spreading to the ductwork. Many units incorporate auxiliary systems to extinguish fires on the cooking surface if the temperature sensed in the exhaust duct exceeds a preset limit.

Final processing of exhaust air is accomplished by electronic precipitators. They are also used to remove particulates from the incinerator exhaust gases. Electrically charged plates ionize particles too small to be filtered out by conventional means.

Filters and precipitators are able to keep emissions from food

service operations within limits prescribed by present laws. However, they may not be enough in the future. Operators say the number of complaints concerning objectionable odors is increasing steadily (1). This may become an even more difficult problem because the particles that cause the odors are not removed from the exhaust gas by filters or precipitators. (50)

Completely Integrated Systems

There is a food service system now in operation in Europe, and soon to be tried in this country, which represents the state-of-the-art today, and will undoubtedly serve as a model for high volume food service operations for many years. It utilizes a "Cooking street" of high-production, automated equipment for performing various types of cooking (38). The purposes of food preparation vary between different operations, but the pieces of equipment used are standard in all facilities. They include a steam cooker, a water cooker, a deep fat fryer, a grill, and a broiler. The equipment considered here is manufactured by the German-based NEFF company (10). This equipment represents, collectively, the most highly automated system of its kind. It is the type soon to be used in its first United States installation.

The Steam cooker. Fresh or frozen vegetables are loaded into the intake bin. They are conveyed by the automatic loading system to a loading drum which portions the product into perforated stainless steel containers for cooking. The containers are mounted on a motor-driven chain which can be adjusted to provide between six and sixty

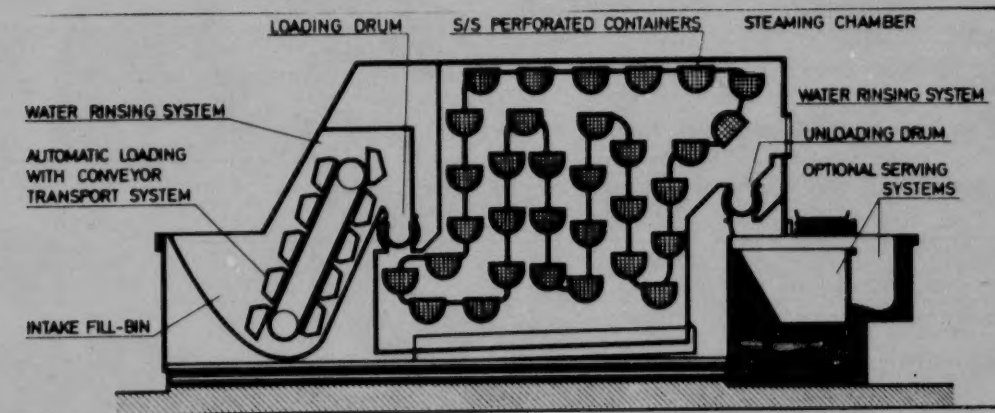


Figure 4

NEFF Steam Cooker (10)

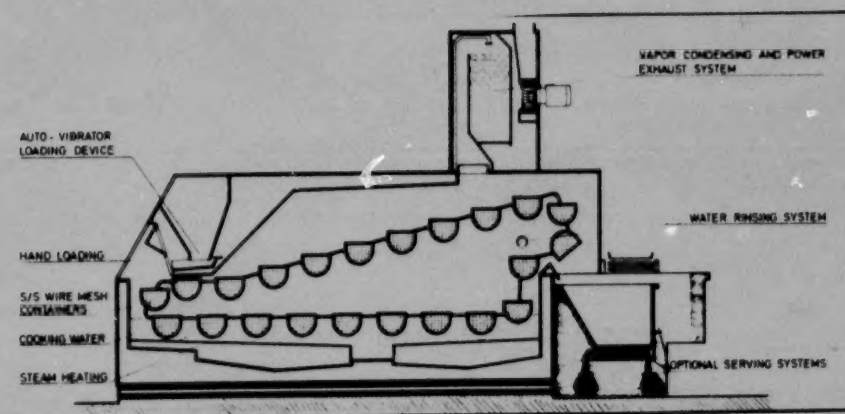


Figure 5

NEFF Water Cooker (10)

minutes of product exposure to the steam atmosphere. At the end of the cycle, the food is transferred to an unloading drum and from there to a built-in receiving bin or a portable, tilting kettle which can be heated or not, as required. Depending on the type of product and cooking time required, the steamer can cook from 400 lbs. to 900 lbs. of food per hour.

The water cooker. The food to be cooked is loaded into wire mesh containers by hand or by means of a vibrator loading device. The containers are passed through water heated to just below the boiling point by steam injection. When the cooking is completed, the product is rinsed with tepid water and unloaded into the desired type of serving unit, either stationary or mobile. Cooking time can be varied from as little as four minutes to as much as forty minutes. The water cooker can produce 500 lbs. of rice per hour with an average cooking time of 20 minutes; 600 lbs. of pasta per hour with an average cooking time of 15 minutes; or 1800 hard-boiled eggs per hour with a cooking time of six to ten minutes.

The deep fat fryer. This piece of equipment is similar to the water cooker in design and operation, but it uses cooking oil heated by electricity. The output of this unit is approximately 1700 portions per hour.

The grill. Products to be cooked are placed by hand on the grill, then moved across the surface by a series of stainless steel bars mounted to a motor-driven chain. The speed can be adjusted to provide from three to thirty minutes of cooking time. At the center of the grill, the product is automatically turned over by a "flipper"

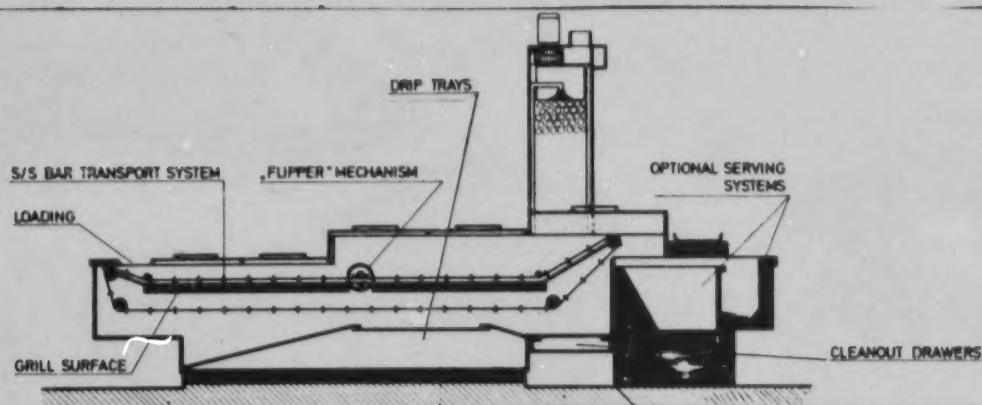


Figure 6
NEFF Grill (10)

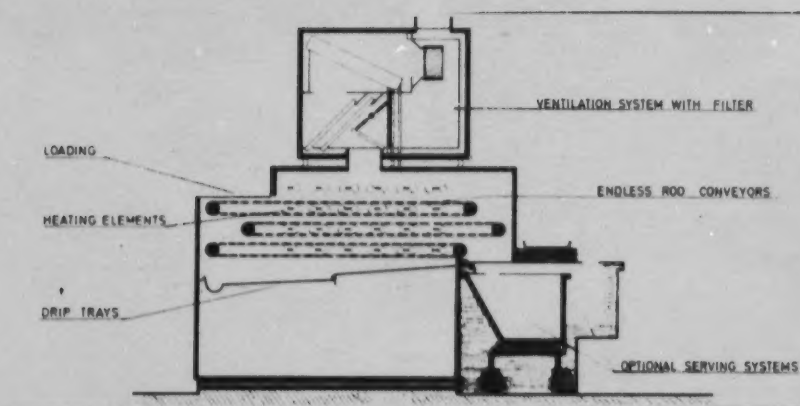


Figure 7
NEFF Broiler (10)

mechanism to provide even cooking on both sides. The food is forced up an incline before unloading to allow grease and oil to drain off. The grill can also be used as a band fryer by using a layer of cooking oil up to $1\frac{1}{2}$ inches on the grill surface. Output of such items as steaks, chops, grilled sandwiches, pancakes, and hash brown potatoes is between 1500 and 3000 portions per hour, depending on the cooking time required.

The broiler. Items to be broiled are placed by hand on a rod conveyor belt. They are transported through infrared heating zones with heating elements above and below the belts. The product drips from the first belt to a second one, and finally to a third belt. Thus, the food passes through the heating zone three times before being unloaded into the desired receptacle. Cooking time can be adjusted between $2\frac{1}{2}$ and 25 minutes. Steaks, chops, hamburgers, sausages, and chicken are produced at the rate of 800 to 1700 pieces per hour, depending on the cooking time.

One use for a system of equipment like the NEFF system is in a "cook-and-serve" operation like a cafeteria. In such an operation, the conveyor belt which runs past the unloading end of each piece of equipment becomes the tray assembly line with each worker along the line portioning one type of food onto the tray. At an installation in Ludwigsburg, Germany, eight workers are able to serve fifty trays a minute. They can serve sixty to seventy trays a minute when they work at full capacity.

An adaptation of this procedure prepares individual trays for short-term storage prior to serving. The items to be heated are stored

in one compartment of a specially-designed transport module while the items to remain chilled are stored in the other compartment. Both compartments are refrigerated while the module is in transit and at the destination until 45 minutes prior to serving. At this time, the heating elements in the module are activated, and the food in one compartment is heated to between 160 and 170 F. The various items for an individual meal are removed from the two compartments, placed on a single tray, and served. The modules are manufactured in two sizes; one will hold 20 complete meals and the other, 40.

The other type of food production system is designed for "cook-and-freeze" operations. It either freezes individual meals or freezes food in bulk. If individual meals are to be prepared, trays are assembled as in the "cook-and-serve" operation, covered, quick frozen, then placed in freezer storage. When food is to be stored in bulk, the product is unloaded from the cooking equipment directly into a "co-fill" unit. This device automatically weighs pre-set amounts of food into steam table pans and places them on a conveyor belt which carries pans to the packaging and freezing area.

The NEFF "cooking street" equipment is designed for efficient, high-volume production, but it features simplicity and reliability. If the work is distributed properly, two people can tend the five pieces of cooking equipment. The food operation at Ludwigsburg can serve 2,800 customers at noon with a total department staff of 22. Another installation in Karlsruhe can serve 5,000 people with a kitchen staff of 19. Another plant is capable of producing 46,000 TV dinners per day with only 74 employees.

The operation of all pieces of equipment is simple, with a minimum of sophisticated and complicated mechanisms. The cooking containers of the steamer, water cooker, and deep fat fryer, the transport bars and "flipper" of the grill, and the rod conveyors and infrared heating elements of the broiler are all removable without tools. The facility at Ludwigsburg has been operating for 16 years with only one maintenance call--to start up the equipment on the first day of operation.

Future Trends

A projection of future trends in food processing and preparation equipment follows in this section. We obtained our projection by looking at the past, at the equipment now being introduced, and at equipment now in the experimental stages. Heat transfer is a fundamental phenomenon involved in all equipment; thus the impact of new developments in this area were given priority. The last portion of this section indicates topics requiring future research to optimize these processes.

General Trends

These trends are evident throughout the food service industry. They do not apply only to certain pieces of equipment or specific types of operations. A close study of these trends may be the key to predicting what types of equipment will gain currency in the future.

Mobility. Much of the new equipment being introduced is available either as stationary units or mounted on wheels or movable bases. This second feature allows it to be used in the most convenient or efficient location for the task being performed. Production lines can be rearranged to suit the material being handled and different types of processing required. Mobile equipment also facilitates cleaning and repair as well as major modifications of the facility.

Flexibility. New equipment is being designed to provide the food service operator with greater flexibility in the use of his equipment.

Generally, this means units that can serve more than one function. Examples of this include combination ovens employing two types of heating, holding cabinets containing heated and refrigerated compartments in the same unit, large refrigerator-freezers that operate at either 40 F or 0 F at the flip of a switch, and fat fryers and steam cookers that can operate with or without pressurization.

Capacity. Both batch-type and continuous-type equipment are being made available with larger output rates. A good example is the new design of ovens and refrigerators which allows a rack of food trays to be wheeled into the equipment for processing. The European procedure of ganging ovens permits a number of racks of food to be stored, handled, and processed as a single group. Also as a result of mass production, alternative means of transporting the food product within the facility have been developed. Racks, carts, conveyors, and rollers move large-bulk packages which are often too unwieldy to be handled by human means alone.

Even with the emphasis on high-volume operations, though, smaller capacity equipment is not being phased out. These units find use in smaller facilities which cannot efficiently utilize large-capacity equipment. In operations where the work load may be highly variable, one or more of the smaller units, instead of larger ones, help prevent wasted space and food.

Process Control. Better control of the various cooking processes is now possible due to improved sensing and control of time and temperature. More accurate thermostats, thermometers, and timers on fryers and ovens, for example, allow closer monitoring of the cooking

process. Automatic termination of the cooking cycle in, for example, fryers with timed basket lifts and steamers that exhaust the steam at the end of the cooking period, prevent over-cooking by human error.

Automation. The increasing use of automated equipment represents an attempt to offset the increasing costs of skilled and semi-skilled labor. Once the optimum time-temperature relationship for a particular product has been determined, the equipment can be programed by a chef or supervisor. Then only unskilled labor is required to feed the product in, monitor the operation of the equipment, and remove the product when it is finished.

The higher number of electrical and mechanical components required by automated equipment can, however, substantially reduce reliability. Methods of overcoming this problem include redundant circuits to provide back-up capability or, possibly, plug-in replacement modules similar to those used in today's electronic equipment.

Energy conservation. Since the recent energy shortage, energy conservation has become a matter of concern in all industries. Designers of food service equipment are devoting more work to improving heat transfer, reducing warm-up time, and avoiding wasted capacity in their units. Recently introduced systems show the results of this work somewhat, and those to be introduced in the future will undoubtedly be even more efficient.

Much controversy exists as to which energy source is appropriate for which equipment. Operators prefer gas-fired equipment, and gas is more efficient overall than electricity (49). But gas is in various degrees of short supply throughout the country and is more

easily shut off to operators than electricity.

Computers. Data processing machines have been used for years to accomplish such standard procedures as payroll and inventory accounting. Today, though, they are being considered for much wider use in the food service industry. Computers can be used to control various cooking processes in response to programed instructions. This helps eliminate human error in processing, and it reduces the skill level required for adequate results.

An early application of computers was in an almost completely automatic drive-in restaurant (30). The customer enters his order by pressing buttons corresponding to menu items on a console; then a "go" button indicates that the order is complete. The computer activates the proper piece of cooking equipment: hamburger cooker, hotdog cooker, potato dryer, fryer for entrees like chicken, beverage dispenser, or milk shake dispenser. The cooked food and computer-produced totaled check are delivered to the assembly man. He matches the checks with the food items and places them on trays, adding such items as pickles and cole slaw. The computer totals all sales at each station and calculates the number of sales, both in units and dollar value, of all menu items.

Another possible computer application could be as a behind-the-scenes manager of a patron's meal in a standard table-service restaurant. When a customer calls for a reservation, the computer, or a person working in conjunction with the computer, would receive the customer's name, the size of his party, and the time at which they wish to eat. It would scan its memory banks to determine whether a table of suitable

size is available at that time, verify the customer's credit rating, ask what he would like for a main course, inquire about the nature of the occasion, and even making dining suggestions. When the customer arrives, the computer would have assigned a table, printed a personalized welcome card, and informed the waiter of any special event to be celebrated. It would print out detailed descriptions of the main dishes ordered and suggest side dishes and appropriate beverages, all based on total food costs, the probability of selling a particular item, the occasion, and what the customer ordered the last time he ate at one of the restaurants sharing the computer.

The waiter would make appropriate notations on the order form and return it to the machine. The computer would then signal the kitchen equipment to extract certain food components from storage and activate the cooking equipment to heat each component to the proper temperature. Instructions would be printed out for the assembly man who would group the components into the classic, familiar dishes. The waiter would deliver the food to the table, giving the computer-produced explanation of each dish, its derivation, components, and the like.

The customer's bill would be printed item by item, allowing him to verify it before signing the check. The computer would retain in its memory what the customer ordered, how much he spent, and the date of any special occasions so that he could be invited in advance of the next occasion to return.

The computer could also maintain an up-to-date account of inventory and food costs, could reorder them when stocks get low, and could print out such information on each waiter as his record in selling

wine, how often his customers return, and how much they spend (30).

Technological Breakthroughs

Every now and then, a breakthrough in the field of engineering, management, or food technology effects the food service industry, allowing it to move rapidly into a era of new concepts and procedures. In the field of engineering, the latest technological advance to have a profound effect on the foodservice industry was the development of the microwave oven. Introduction of the more efficient high-power microwave power module may bring about significant changes by making microwave processing practical on a large scale that it has been. But these changes will not be as radical as those caused by the original introduction of microwave processing.

A review of research in heat transfer presently being conducted reveals no imminent technological breakthroughs on the order of magnitude of the development of microwave processing. However, research on the heat pipe discussed earlier may reveal applications which will affect the future design of food service equipment. Because of the pipe's ability to pass large quantities of heat quickly and maintain a surface at a constant temperature, certain types of food service equipment may be capable of more efficient energy conversion by incorporating heat pipes into their design.

One piece of equipment to which heat pipe technology has already been applied is griddles. The purpose of the research was to determine if a heat pipe griddle could be constructed to provide a uniform temperature over the cooking surface, a short warm-up time, and accurate

temperature control. The process also had to be relatively inexpensive, reduce gas consumption, and be capable of operating on commercial burners with only minor modifications. A summary of the performance of two griddles as described by Basiulis (3) appears below.

	<u>Range "A"</u>	<u>Range "B"</u>
Overall size	36" X 26"	36 1/2" X 32 3/4"
Cooking surface size	35" X 22"	35" X 28"
Griddle thickness	1 inch	1 inch
Rated burner capacity	66,000 BTU/hr.	140,000 BTU/hr.
Warm-up, room to 400 F	10 min.	5 min.
Warm-up, pilots to 400 F.	6 min.	3.5 min.
Cook 1/4 lb. frozen hamburger patties	5 min.	4 min.
Temperature distribution at 400 F	<u>+5 F</u>	<u>+5 F</u>

Heat pipes may be used to best advantage in equipment where large quantities of heat must be transferred and where warm-up time is now considerable. Besides griddles, pieces of equipment which seem to be logical candidates for heat pipe application are fat fryers and, possibly, convection ovens.

Future Research

We have stressed in this discussion the importance of heat and

mass transfer in the design and fabrication of food processing and preparation equipment. We have also indicated that extraordinary research activities in the past 20 years in heat transfer have resulted in a significant increase in our knowledge of the basic fundamentals of heat transfer and our ability to design and predict heat transfer rates in equipment. One may well ask why has only a limited amount of this knowledge been applied in the food processing and preparation industry. The NEFF "Cooking Street" concept, which is only now being introduced into the United States, was conceived and developed in Germany over sixteen years ago.

The basic answer to these questions is one of communications. There is for all practical purposes only a very limited line of communications. There is the food service operator, the dietitian, the food technologist, the nutritionist, and the engineer with a knowledge of heat and mass transfer. This lack of communication has meant that the problems possessed by one group have not been sufficiently well defined in the vocabulary of another group to encourage or even allow assistance in obtaining solutions. Indeed one sometimes wonders if the groups are even aware that they have serious equipment deficiencies. This communication problem must be resolved on all levels, at the universities and research laboratories, at the industrial design and fabrication level, and at the lowest operating level.

With an improvement in communication a detailed specification of an acceptable thermal environment for the preservation and preparation of food can be obtained by the food service operator, the nutritionist, and the food technologist. The heat transfer engineer can then design

a system that will optimize the process from the standpoint of cost, time, energy consumption, or labor involvement. Automatic or programmable ovens will appear that respond to a data card attached to the packaged food product. It will be removed at time of preparation and inserted into the oven's controller, and the product will be processed in the optimum way for flavor and nutrition retention.

But significant advance in these areas will be possible only if

- 1) Improvements in technical communication between the engineering community on the one hand, and the food service operators, the food technologist, and the nutritionists, on the other, are obtained; and
- 2) An extension program is developed to define clearly the optimum thermal environment needed for the processing and preparation of food products.

APPENDIX

Basic Principles of Heat Transfer

There are three basic modes of heat transfer: conduction, convection, and radiation. The latter two modes often occur simultaneously, thus the total heat transfer from a surface can be the sum of the convective and radiant heat transfer.

Heat Conduction

Conduction is the process by which heat flows from a region of higher temperature to a region of lower temperature within a gas, solid, or liquid by direct molecular interaction and without appreciable displacement of the molecules. The energy possessed by matter is proportional to the sum of its molecular kinetic energy and the relative position of the molecules. It is called the "internal energy." The internal energy is directly proportional to the temperature of the matter. When higher internal energy molecules (high temperature) come in contact with lower internal energy molecules, part of their energy is transmitted by either the elastic impact of the molecules or the diffusion of faster moving electrons, and heat is said to be "transferred by conduction."

The rate at which heat is conducted is given by Fourier's Law (1822). It is important to note that the heat flux is a vector and thus has direction as well as magnitude. The flux is proportional to the thermal conductivity, K , the

area of the section perpendicular to the flow of heat, A , and the rate of change in the temperature, T , with respect to the distance measure in the direction of heat flow. For one-dimensional heat flow the expression is

$$q_x = -KA \frac{\Delta T}{\Delta x} \quad (\text{Fourier's Law})$$

where the heat flows in the direction of the positive x axis. An increase in either the thermal conductivity or the temperature gradient, $\Delta T/\Delta x$, will result in an increase in the rate of heat transfer. An order of magnitude grouping of the thermal conductivities of some common materials is given in Table 1. For the one dimensional flow of heat, the concept of thermal resistance to the flow of heat is often introduced and is defined as

$$R_K = \frac{\Delta x}{KA}$$

Table 1

Thermal Conductivity of Different Materials

<u>Material</u>	<u>K, Btu/hr-ft-F</u>
Gases at atmospheric pressure	.0004-.10
Insulating materials	.02 -.12
Nonmetallic liquids	.05 -.40
Food products	.0074-.78
Nonmetallic solids	.02 -1.5
Alloys	8 -70
Pure metals	30 -240

In many instances the boundaries of the surface are not perpendicular and one encounters two- or three-dimensional heat transfer. The condition in each direction is given by Fourier's Law, and a limiting process is used to arrive at an energy balance describing the transfer of heat. The energy equation, which is a partial differential equation, must be solved for each particular problem using the appropriate boundary conditions.

In many applications the rate at which heat is transferred is not steady but is time dependent. The temperature distribution in the material is thus dependent not only on the above noted items but on the rate at which energy is stored. The energy storage is dependent on the density, ρ , and specific heat, C , of the material. It is usual to utilize the thermal diffusivity, $\alpha = \frac{K}{\rho C}$, in the analysis of transient conduction problems. Representative values of thermal diffusivities for different materials are presented in Table 2.

Table 2

Thermal Diffusivities of Different Materials

<u>Material</u>	<u>$\alpha - \text{ft}^2/\text{hr}$</u>
Gases	.6 - 10
Insulating material	.01
Nonmetallic liquids	.002 - .005
Food products	.0044 - .0068
Nonmetallic solids	.006 - .02
Alloys	.15 - 1.2
Pure metals	1.6 - 4.4

The most simple transient analysis is denoted as the lumped parameter analysis and assumes that there is negligible internal temperature variation in the solid. The rate at which heat is stored or removed from the solid is related to the ease with which heat is transferred from the body to the surrounding fluid. Assume that the fluid is at a temperature T_{∞} and the body is initially at a temperature of T_0 . The temperature distribution at any time θ is given by

$$\frac{T - T_{\infty}}{T_0 - T_{\infty}} = e^{-\frac{hA}{\rho CV} \theta}$$

where A is the surface area, V is the volume of the material, ρ is the density, C is the specific heat and h is the convective film coefficient (to be discussed in more detail in the convection section). The rate at which heat is removed or added to the solid is given as

$$q = C\rho V(T_{\infty} - T_0) \left[1 - e^{-\frac{hA}{C\rho V} \theta}\right]$$

and indicates that a large surface area to volume configuration ratio is desired for highest heat transfer. The lumped parameter analysis is valid for many of the conditions encountered in food processing and preparation with an error of less than 5 percent introduced when $hV/AK_s < .1$ where K_s is the thermal conductivity of the solid.

When temperature gradients can not be neglected in the solid, the conduction heat transfer analysis becomes more complex; an interested reader should consult a basic heat

transfer book like Kreith (26) or a more specialized book like Schneider (45). A useful relationship to remember is that, for a large number of cases, the rate of heat transfer is inversely proportional to the square root of the thermal diffusivity and time, while the total heat transfer is proportional to $K_s \sqrt{\theta/\alpha}$.

Heat Radiation

In a very broad sense radiation is associated with all kinds of electromagnetic wave phenomena, thermal, light, and so forth. They usually differ only in their respective wave lengths. In heat transfer, the radiation is associated with the temperature of a body, and it can be transported through a transparent medium or through a vacuum. All bodies thus emit thermal radiation with the level determined by the temperature of the body and the characteristics of the radiating surface. The rate of heat transfer is determined not only by the radiating body but also by the radiation characteristics of the receiving body and the geometrical relationship between the bodies since radiation travels in a straight line path. Incident thermal radiation on a surface will be either absorbed, reflected, or transmitted through the solid. The general expression for the transfer of heat by radiation is

$$q_r = \sigma A_\epsilon F_{1-2} (T_1^4 - T_2^4)$$

where σ is the Stefan-Boltzman constant ($.1714 \times 10^{-8}$ Btu/hr ft² R⁴), A is the surface area (ft²), F_{1-2} is geometrical

shape factor, F_e is a factor which takes into account the radiation properties of the surface. The temperatures are given in R ($460 + F$). This relationship indicates the dominating dependence of the radiation heat transfer on the temperatures of the radiating bodies. If a body is at 100 F and the surrounding either at 200 F or 500 F, the higher temperature will transfer 390 percent more heat to the enclosed body.

Heat Convection

Convection heat transfer is the method by which heat is transferred between a solid and a liquid or gas. The complete process is quite complex but generally takes the following form: Heat flows from the interior of a solid to its surface by the process of conduction, as previously described. Heat is then conducted from the surface to the particles of the fluid adjacent to the surface, thereby increasing the internal energy and temperature of the particles. The warm particles move away from the wall into the cooler fluid, mix with the fluid and transfer part of their energy. If the fluid movement takes place because of density differences created by the temperature gradients (buoyancy effects) the heat transfer process is referred to as "natural" or "free convection." When the movement of fluid is the direct result of an external source such as a pump or fan, the process is denoted as "forced convection." The rate of heat transfer

may be calculated using the following relationship

$$q_c = hA\Delta T$$

where A is the surface area, ΔT is the temperature difference between the surface and fluid and h is the convective heat transfer coefficient. The magnitude of h is dependent upon the type of convection (natural or forced), the type of flow (laminar or turbulent) and the fluid. Representative values of film coefficients are given in Table 3.

Table 3

Convective Heat Transfer Coefficient

<u>Condition</u>	<u>h Btu/ft²hr F</u>
Steam condensing	1000 - 20,000
Water, boiling	500 - 10,000
Water, forced convection	50 - 2,000
Oil, forced convection	10 - 300
Air, superheated steam forced convection	5 - 50
Air, natural convection	1 - 5

To illustrate the significance of these results on food preparation, it can be seen that if the temperature difference is held constant, a tenfold increase in the rate of heat transfer will result if one switches from a natural convection to a forced convection unit.

Glossary

Change of phase. In this study, three physical phases concern us: solid, liquid, and gas. When certain conditions--temperature or pressure, for example--to which a substance is exposed change, the substance may itself change from one phase to another. For example, water undergoes a change of phase to ice or to and from steam with certain temperature changes.

Conduction. Conduction is a method by which heat diffuses within a body, or from one body to another, or from a region of high temperature to a region of low temperature, with no gross molecular movement.

Convection. Convection is a means of heat transfer wherein heat is transported from one point to another by the movement of hot material between those two points. The medium that transfers the heat is a fluid, either liquid or gaseous.

Convective film coefficient. In convective heat transfer, there is always a stagnant layer of fluid next to the solid substance. The convective film coefficient is a measure of how well heat can be transferred through this stagnant film of fluid. The units are typically expressed in (calories)/(seconds) (cm^2) (degrees C).

Dielectric properties. Dielectric properties are those properties that describe the molecular reaction of a substance to an electric field. Certain of these properties determine to what extent a substance will absorb microwaves and thus undergo a rise in temperature.

Electromagnetic waves. Wave phenomena characterized by variations of electric and magnetic fields are electromagnetic waves. Radio waves, heat, light, x-rays, microwaves, and many others are electromagnetic waves differing only in frequency.

Fluid mechanics. Fluid mechanics is the study of the mechanical properties of fluids and the laws and forces governing their behavior under both static and dynamic conditions.

Heat and mass transfer. This term denotes the movement of heat or mass from one body or substance to another, or within the body or substance itself. In food service applications, we are concerned with the transfer of heat from a body during freezing or refrigeration and to a body during cooking. Mass transfer considerations in this application are generally limited to the moisture loss that occurs during cooking operations.

Internal energy. Internal energy is the energy contained within a substance due to its state, not to its bulk movement or position. In our discussion, the internal energy of a substance is a measure of its temperature and specific heat.

Lumped parameter analysis. The study of a system in which the properties (temperature, pressure, density) of each substance are considered to be constant throughout the body is known as a "lumped parameter analysis." Although gradients and variations exist, an analysis of this type can provide a good approximation of the reaction of the system.

Radiation. Radiation is the transfer of energy from one point to another by means of electromagnetic waves. Radiation striking a body is converted to heat due to the molecular absorption of the radiant wave energy.

Specific heat. Specific heat is a measure of the amount of heat required to raise a mass of a substance over a certain temperature increase. Common units are (calories)/(degrees C) (grams). The higher the specific heat, the more heat is required to raise the temperature of a given mass. Likewise, more heat is released by a given mass when it undergoes a drop in temperature.

Standing waves. Due to the regular rectangular shape of an oven cavity, each successive wave of microwave power will follow the same path as the previous wave. It will reflect from metallic surfaces throughout the oven until absorbed by the product. Where no waves pass through the product, heating will take place only by conduction of the heat from higher temperature areas of the oven. If two wave paths cross within the product, excessive heating occurs. For this reason, a

diffuser or "stirrer" is required to disperse the microwaves in different directions when they are directed into the oven cavity.

Stefan-Boltzman constant. This proportionality constant relates radiation from a body to the fourth power of the temperature of the body. Its numerical value has been determined experimentally.

Thermal conductivity. Thermal conductivity is a measure of how well a substance conducts heat. Units are typically represented as (calories)/(cm²) (degrees C). Materials with high thermal conductivities, like metals, conduct heat readily; those with low thermal conductivities act as insulators.

Thermal diffusivity. The quantity K / C_v where K is the thermal conductivity of the substance, ρ is the density, and C_v is the specific heat is the thermal diffusivity of a substance. The magnitude of this quantity is a measure of how quickly a body with a non-uniform temperature will approach equilibrium.

Thermocouple. A thermocouple is a device consisting of two wires of different metals welded or soldered together. As the temperature of the junction is increased, a larger voltage difference is produced between the wires. This voltage can be measured and the temperature at the juncture calculated.

Thermodynamic properties. The thermodynamic properties of a substance are those properties that determine its behavior when heat is

transferred into or out of a body of that substance.

Thermister. A thermister is a device made of semi-conductor material that exhibits a change in resistance when subjected to a change in temperature. The resistance can be measured and the temperature calculated.

Turbulent flow. Turbulent flow is the combination of a uniform fluid flow and irregular eddy currents.

Food Processing and Preparation Equipment:

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III

FOOD PROCESSING METHODS: THE STATE OF THE ART
AND ITS FUTURE EFFECT ON FOOD SERVICE

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FOOD PROCESSING METHODS: THE STATE OF THE ART
AND ITS FUTURE EFFECT ON FOOD SERVICE

Introduction

Food science obviously contributes a great deal of information to the food service discipline and industry, and the role of food science and its relationship to the food service industry is the focus of this report. More specifically, our approach has been to provide a thorough discussion of some of the more important food processes that will almost certainly affect the food or the food preparation systems required by the food service industries of the future. For example, how the food reaches the food service establishment will certainly have some bearing on the type of preparation that goes on at the serving site. These preparation procedures have traditionally ranged, and will continue to range, from simple heat-and-serve to taking the raw food and preparing it from scratch. The procedures will change little; their use ratios will change substantially.

In the past, there has been altogether too little communication between the food scientists and technologists on the one hand, and the food service practitioners on the other. While both groups endeavor to improve food quality and lower its cost, they have tended to operate exclusive of each other. This Project has demonstrated that a unified approach to the problems of both interest groups certainly would work

to their mutual advantage. There exist great areas of overlapping interest--which this Project has served to point out repeatedly over the preceding six months.

We refer to the subject matter covered in this report loosely as "food science," but it might be more accurate to call it "the food processing areas of food science." Even with this more restrictive partitioning, however, we are left with an extremely complicated, multi-faceted area. We attempt to provide our reader with a knowledge of the various processes being used in the industry today and how these processes might be used to produce the product ultimately used by the food service industry. It is not a comprehensive view of all the processes, rather it tries to convey the nature of each process and the extent to which it is presently being used by the food processing industry.

The technological information for producing new food products, along with the complementary, sophisticated procedures, is available now. To what extent this knowledge will be used in the food service industry in the next few years will depend on the type of individuals charged with the decision-making responsibilities and the training they receive. Will the food service industry concentrate solely on business or will it become more involved, with the food scientists, in the ramifications of the rapidly changing food processing techniques? We cannot answer this question, but in this report, we have attempted to isolate and discuss the considerations that will shape an answer soon.

Food Dehydration: The Most Widely Used Method
of Food Preservation

Although the major products being dehydrated in the United States today are essentially the same as they were in 1960 (sugar, starch products, coffee, milk products--especially non-fat milk and whey--and flour mixes, with good markets for breakfast and pet foods, pasta products, and dried fruits and vegetables as well), since that time there have been other changes. The production of dried breakfast foods, mixes, and potato and corn chips has increased, for example, and much of the production of processed coffee has been taken over by freeze-drying. Also other countries now surpass the U.S. in drying fruits and vegetables. The methods of dehydration, however, have remained basically unchanged. In 1963, 55 percent of all dried products were air-dried, 40 percent were spray-dried, and less than 5 percent were dried by other methods. It is probably still true that these two methods account for most industrial dehydration.

(Karel, 44)

Air Drying

Air drying is the dehydration of solids in air, which is accomplished by exposing foods to heated air in direct dryers. Sometimes these dryers are used with indirect dryers, which heat the surfaces on which the food is placed. Primarily convection provides the heat transfer, but additional heat may be supplied by radiation or conduction, using batch dryers (tray dryers, kiln dryers, and some types of fluid beds) or continuous dryers (tunnels, rotary dryers, and belt or band dryers. (Karel, 44) Often the manufacturer adopts

the tunnel dryer, which is by far one of the most flexible systems in commercial use. In its simplest form the tunnel dryer is a rectangular structure (whose dimensions vary greatly, depending on the capacity of the plant), which will accommodate trucks containing trays, spread uniformly with the product to be dried. The tunnel is essentially continuous and the trucks gradually enter one by one and are removed when equilibrium of the product is established. Tunnel systems are classified according to how the air traverses the product, the single-stage parallel air flow being one of the simplest systems. In this one, the "wet" material first encounters the driest, warmest air, then leaves the dryer at the cooler end of the tunnel. Although the highest rates of evaporation are achieved initially, there is little danger of overheating the product since the surface temperature of the food is below the dry bulb temperature due to heat loss through evaporation. The product is protected in the latter stages of drying because the air is getting progressively cooler. This cooler air also causes a decreased drying rate in the latter stages. The ultimate disadvantage, however, is that a product of very low moisture cannot be produced no matter how long the tunnel is. Commercial plants use this system mainly for drying grapes; however, it is usually used in combination with a counterflow system.

In the single-stage countercurrent flow dryer, air is directed against the movement of the product. The dry product leaving the dryer encounters the hot and dry air entering the system. The "wet" product, then, is initially exposed to very slow drying conditions. However, provided precautions are taken not to overheat the product,

it ultimately has a lower moisture content than it would have if processed by the previously mentioned system. The counter flow system is more economical to operate than the parallel flow and is widely used for commercial production, mainly for processing dried vegetables. The greatest problem with the system is product shrinkage. The dried product has a relatively high density and slow reconstitution properties, whereas the parallel flow system produces a dried product with much less shrinkage and a lower density.

Double-stage dryers are available with both countercurrent/parallel flow and parallel/countercurrent flow. The bulk of the commercial two-stage plants in this country are the latter type, probably because of its more uniform drying and its high output of good quality products. The system produces high initial evaporation and, often in practice, the first stage is shorter than the second to compensate for the latter's low rate of drying. However, equal length tunnels are widely used, and it is possible to place them side-by-side for loading and unloading at the same end. In many systems, air from the secondary tunnel is used to supply the parallel flow system. The advantage of this is that it allows the temperature of the air in either system to be adjusted as desired.

The chief advantage of the three-stage dryers is that they are more flexible and can achieve nearly optimum conditions for drying a wide range of products. However, the few of these in operation use three tunnels with countercurrent air flow. An important implication of these dryers for the future is their total recirculation system which solves the odor problem associated with onion and garlic

dehydrators. The method involves interstage heat transfer with dehumidification.

Another type of dryer is the bin-type finish dryer which serves as a place for equilibrating temperatures, obtaining final moisture levels, and storing dried products prior to packaging. Basically, these dryers are cylinders through which blows warm air at a velocity not greater than 100ft^3 per minute per ft^2 . This dryer provides a low-cost method of removing moisture from particular products during the slowest stages of drying. Both the static and portable units require 24 to 36 hours to reduce the moisture content of vegetables from 10 percent to 5 percent.

In the conveyor-type dryer, which resembles the tunnel dryer, material is conveyed through a hot air system on a continuous moving belt, with the result of reduced handling costs. The wet material is loaded uniformly about 6 to 8 inches deep onto a belt made of either woven metal mesh or interlocking perforated plates and is dried initially by air blowing through the bed and finally by air passing down through the bed. The latter prevents material from being lost from the system due to changes in density during drying. Belts vary from 30 to 60 feet long and from 6 to 100 feet wide. By sectionalizing the system, it is possible to control independent flow rates, temperatures, and humidities (which is essential for high capacity water removal) and thereby receive optimum output and quality. Also, it is necessary to remove the material at a moisture level of approximately 15 percent to avoid excessively long belts and the waste of evaporating capacity. (Holdsworth, 43)

Modern industry in general has increased instrumental analysis feedback control, and automatic operation of process lines, but these developments have lagged in food processing for at least three reasons: (1) food materials are complex and difficult to describe in simple engineering properties; (2) the measurement of on-line and feedback control with regard to food processing is difficult; and (3) it is hard to find food technologists with adequate background and experience in engineering. Some progress, however, has been made. Extensive on-line moisture measurements are now available and one control scheme for a fluid bed dryer is based on three temperature measurements: inlet air temperature, outlet air temperature, and the temperature of the air wet bulb. Control is maintained by monitoring the temperature of the inlet air to compensate for the changes in the other temperatures. (Karel, 44)

The major problem in air drying solid foods is that the drying rates must be limited as moisture control decreases because of the low diffusibility of the moisture. The associated problems of shrinkage and organoleptic changes lower the quality of the product. Air-dried solids also run the risks of (1) poor rehydration, (2) burning and flavor deterioration during drying, and (3) lipid oxidation, as well as oxidation of lipid-soluble pigments, vitamins, and some water soluble compounds both in drying and storage.

Researchers are continuing to look for ways to counteract the aggregation in solids during dehydration that limits both the drying and rehydration rates. (Karel, 44) The demand for better and faster reconstitution in dehydrated products led to the development of the

"explosion puffing process" by the United States Department of Agriculture (USDA) at the Eastern Utilization Research and Development Division near Philadelphia. The process is now recognized as one of the most significant developments in dehydration technology, for its products have many of the desirable attributes of freeze-dried food, and they can be processed at a cost comparable to that of conventional air drying.

Explosion puffing reduces rehydrating and reconstituting to a few minutes. In the process, pieces partially dehydrated by a preliminary stage drying are heated in a closed rotating cylinder known as a "gun" until a predetermined internal pressure has been reached. The gun is then discharged instantly to atmospheric pressure. During the process a certain amount of water is vaporized, but more importantly, the explosive, or flashing, conditions result in a highly porous network of capillaries within the particles. This porosity enables the final dehydration to be achieved much more rapidly (in about one-half the time) than would be possible with conventional dried products. It also allows the product to reconstitute very rapidly.

At present, explosion puffing can produce dehydrated carrots, beets, white and sweet potatoes, celery, and fruit; it works especially well with apples and blueberries. (Holdsworth, 43)

Another possible way to combat aggregation of solids during dehydration is to freeze and thaw foods prior to drying in order to increase internal porosity and ease of mass transport. The idea itself is not new, but a new method of carrying it out has been patented.

In this method, food that has been previously pressurized with 500 to 1500 psig of methane, nitrogen, CO₂, air, freon, or ethane is frozen. The pressurized frozen substances are then air dried, and they retain their shapes. The developer does not fully understand the phenomenon himself, but he believes that bubbles of gas are retained within the solids during melting and drying, thus preventing shrinkage. (Karel, 44)

A third method of preventing shrinkage has also been proposed. This method involves irradiating dried vegetables with ionizing radiation to produce scission of some polysaccharides, with the result of improved rehydration and texture. However, the use of ionizing radiation is not currently allowed by the Food and Drug Administration. (Karel, 44)

One recently proposed process for dehydrating solids in air is the fluidized bed, which has been used in the food industry for freezing, mixing, transporting, heating, agglomerating, and drying. This system has the advantage of a simple design, intimate gas-to-particle contact, and uniform particle exposure to air without mechanical agitation. It is an extremely simple piece of equipment that can be made continuous if some back mixing can be tolerated.

However, conventional fluidized beds have several disadvantages which restrict their use in the food industry to the preparation of food powders. (Brockman, 20) Work on centrifugal fluidized beds (CFB) by the USDA led to the conclusion that drying food pieces in a CFB with relatively high air flows may be self-limiting, even when only partial drying is desired. The rate increases obtained in early drying-stages may be more than offset by the rate-retarding effects of

a skin-like layer of collapsed surface tissue which forms on the food pieces. As the drying process continues, this tissue becomes increasingly resistant to heat and moisture. (Lazar and Farkas, 48) However, in 1972 the USDA modified the design of their CFB. The new design subjected the food particle to a centrifugal force greater than the gravitational force during fluidization, with the result that the CFB could accommodate different sizes of food pieces, as well as alter the amount of heat required in processing them. The new process increased the apparent density of the particle and allowed smooth, homogeneous fluidization, which could be achieved at any desired gas velocity by varying the centrifugal force. Also, increased gas velocity can provide improved heat transfer at moderate gas temperatures without the problem of scorching or surface heat damage associated with higher gas temperatures. The USDA successfully blanched, dried, and puffed potatoes, apples, and carrots with their modified CFB. They are now working on equipment for continuous processing and on techniques for ensuring uniform product flow down the length of the CFB cylinder. (Brockman, 20) Recently peas, beans, diced vegetables, potato granules, onion flakes, and fruit juices have been successfully dried on conventional fluidized beds. (Holdsworth, 43)

A novel idea for increasing the drying rate of foods processed by the CFB has been examined by Bartolome, et al. (7), who found that shorter drying time and lower drying temperatures were possible when forced air drying of potato cylinders was coupled with longitudinal standing waves of a maximum near 8,100 cps. Then researchers felt their method could have commercial application; however, they

cautioned that to conserve power and to minimize noise, standing waves should be used and drying equipment should be designed specifically with this usages in mind.

Spray Drying

Nearly as important as air drying to the industry is spray drying, which is used to process a wide variety of products, including coffee, eggs, milk products, bananas, blood, cake mixes, casein and caseinates, cheese, citrus juices, corn hydrolyzates, fish concentrate, potatoes, protein from various plant sources, soy isolates and hydrolyzates, starch and starch derivatives, tea, tomato puree, yeast, cream, ice crea, and yogurt.

In the process of spray drying, a liquid or paste is sprayed into a chamber, where it contacts a stream of hot air and is dehydrated. The dry particles, suspended in the air stream, flow into the separation equipment where they are removed from the air, collected and packaged, or subjected to further treatment (such as instantizing). Each step constitutes a complicated and delicately-balanced engineering operation (Karel, 44)

Spray drying often eliminates the need for filtering or reducing the size of particles. Fourth, spray drying allows for coating the particle with another substance. Finally, a continuous spray drying system eliminates all manual handling of the product, thus producing lower labor costs, improved working conditions, better product recovery, and more consistent products.

Unfortunately, there are some problems. Spray drying is more expensive than most other air-drying techniques because the thermal

efficiency is often lower than that of other types of dryers. Therefore, higher fuel and power costs must be set against the savings in manpower in a continuous system. However, cost becomes markedly less as the capacity of a plant increases. Second, although spray-drying is used for heat-sensitive materials, there is a greater potential for thermal damage with this method than with the still more expensive freeze-dehydration method. Third, a major problem still exists in the equipment. The atomizer determines the size of the droplets and is the most important feature of the spray dryer. But threads of liquid tend to be uneven, and when the distribution of particle size is uneven, the droplets interact and coalesce, which results in a lower-quality product. One reviewer notes that apparently there has been no drastic new developments in the last few years in rotating disc atomizers and pressure nozzles. Recently, sonic and ultrasonic droplet production have received attention, but they have not yet been applied by the food industry. (Karel, 44)

The main aim of spray drier design over the last 25 years has been to achieve high overall thermal efficiency with high throughput. Large plants with the capacity to spray-dry 6000 to 7000 gallons of liquid per hour are becoming common, with most major developments concentrating on milk products. Many of these plants use automatic air temperature control units, and other components of the plant, including filter replacement, are also becoming automatic. More drying chambers are being installed in the open, reducing building costs. But the recent concern over air pollution and the attendant legislation will undoubtedly require improved methods for separating powder from

waste. Also recently, drying procedures have been modified for filled milk and other specialty items.

Spray-drying continues to be important for producing dried eggs and instant coffee (although agglomeration and freeze-drying now have the interest of coffee processors) as well as fruits and tomato products.* However, one problem is that products with a high content of sugar and other soluble solids tend to adhere to the walls of the drying chamber. Two solutions, modifying the process and adopting various additives, have been suggested, but at present both are too costly to be commercially feasible. Very recently, however, a dual dryer was developed which atomizes liquid products at the top of a spray-drying chamber, mixes them with heated air, and then directs them onto a screen mesh conveyor belt. The partially-dried particles form a mat and are then circulation-dried. The developer has found this method successful for processing calf starter, whey, and cheese. (Karel, 44)

In conclusion, the continuous spray-drying process produces a high-quality, economical product and is likely to continue to dominate liquid food processing since it is a well-established method that probably will not experience frequent, drastic changes and innovations.

(Karel, 44) In fact, it will no doubt become more widespread as it finds applications among newly developed products from the foodstuff and polymer sectors. (Lyne, 53) For example, the spray-drying of fruit-milk protein combinations may be of substantial importance in the future because milkshakes, yogurt, and flavored dairy drinks are popular with consumers. (Karel, 44) Also, with the current attitudes

* The world's largest egg drying facility is in Riverside, California.

on pollution, an increasing number of effluents will be concentrated and spray-dried to become a saleable product instead of being put down the drain. (Lyne, 53)

Recently, a great deal of research has centered on "instant" powders produced from various foods by spray-drying. (The term "instant" implies a rapid and complete rehydration in water or another liquid.) The industry has produced these instant powders through a combination of surfact treatments and agglomeration. The surface treatments include incorporating surface-active materials into the food to improve its ability to absorb moisture; coating spray-dried products with an additive that increases its ability to absorb moisture; and imbedding primary particles in a substrate which, although soluble in the rehydration liquid, keeps the particles separated during their initial contact with water. Also the porosity of individual particles increases when freeze drying or foam drying are substituted for spray drying. The other method, agglomeration, may be accomplished in two ways: either as part of the spray-drying process or, more commonly, as a later step. In this latter method, the spray-dried powder is carefully rewetted and the particles are brought into contact and allowed to grow into aggregates. The aggregates are then redried, cooled, and separated by size.

Several companies have developed processes for making instant milk powders. These processes vary primarily in the type of equipment they use for each of their steps. Most of the methods developed for milk can also be applied to other spray-dried particles, including sugar-containing mixtures.

The recent "agglomeration boom" in the coffee industry is a controversial subject. Some feel that there is no good technical reason for agglomerating spray-dried coffee and that the trend toward agglomeration is a sales gimmick promoted by companies trying to imitate the appearance of the excellent freeze-dried coffee in order to fool the public. Further, since agglomeration is only feasible for the large processor, some look on it as an attempt to force the small processor out of business. (Karel, 44)

Foam Drying

A great deal of research and development over the last 25 years has been directed toward adapting foam-drying techniques to liquid foodstuffs. Substantial work has been done on developing processes, equipment, and products; on understanding the basic process mechanism; and on measuring product quality and storage stability. Early findings are favorable, good processing definitions exist, and suitable equipment is available. But foam-drying technology, with the possible exception of gas-inflation spray drying, is not yet widely used. Hertzendorf and Moshy (41), finding no reason given for this in previous research, have proposed a subjective critique (which this discussion is primarily based upon) explaining why foam-drying techniques are not commercially used. As they see it, the primary reason is that foam drying is more expensive than conventional spray drying and drum drying. Therefore, if a satisfactory product can be obtained from any of these methods, there is no incentive to use foam drying unless it produces a better quality product. Further, foam drying is not as unique as the still more expensive vacuum freeze-

drying process, which dries solid material better than any other dehydration method. Therefore, in the future foam drying will probably be directed toward specific types of products, namely relatively expensive, heat-sensitive fluid materials. In fact, this is the general direction foam drying has taken in the past.

When all aspects of foam drying are considered, it is a relatively rapid process that does not require high temperatures. While the foam structure of the product assures its rapid reconstitution, this same structure presents a storage problem since foam-dried products are bulkier than those processes by other dehydration methods. Aroma retention is another problem and odd-back techniques are required for some products. Corn syrups have been found to prevent undue hygroscopicity.

There have been two major modifications of the original foam-drying process. The first is the "crater" method, in which a layer of foam about 1/8-inch thick is spread on an aluminum tray with 1/8-inch diameter holes. A blast of air is shot through the holes in such a way that craters are formed in the foam sheet. This enlarged foam surface allows for an increased drying rate. The second modification is the "spaghetti" method. Strips of foam are extruded onto a plate, increasing the surface area and thus the mass transfer. The highest throughput is obtained when threads of the thinnest diameter are dried at the highest possible temperature. Either process produces a product with very low density. The density is increased by passing the powder through heated double roll compaction units which removes the very fine air bubbles that tend to show up in the

reconstituted liquid. Density is also desirable because it makes the product easier to handle. (Holdsworth, 43)

There are several methods of foam drying. What was originally known as "vacuum-puff drying" has been converted into a continuous process called "continuous vacuum-belt drying." This method was originally used in the production of instant coffee and soluble tea, but the development of successful and significantly cheaper spray-drying techniques for these products has caused vacuum dryers to be replaced with spray-dryers. The vacuum-puff dryers are presently used for processing citrus and other fruit beverages, which are relatively expensive commodities. Citrus products, however, have not been amenable to more conventional dehydration techniques. Recently, with more success, the Eastern Regional Laboratory of the USDA test-marketed a vacuum-puff dried milk that could be sold at about a 21¢ per quart equivalent. The "milk" was packaged under nitrogen in cans containing the equivalent of one quart of fluid milk and was called "Dairy Fresh." The product sold well for a new item, indicating a good potential for commercial success. Further, consumers rated it favorably with regard to dispersibility, storage convenience, cost, and richness; in fact a great majority considered it as good as or better than fresh whole milk in all regards. Curiously, the sales of "Dairy Fresh" seemed to have no effect on the sales of other dairy products. Apparently, it was purchased for special uses, thus suggesting additional markets for milk. The USDA has proposed a plant that would operate 24 hours a day, 250 days a year, and produce 62,000 quart equivalents of "Dairy Fresh" each working day. The product would be packaged in No. 10 cans for

institutional use. Of course, the price of 21¢ per quart equivalent would probably have to be higher now because the higher price of raw milk would influence the selling price. However, if product quality and storage stability are as good as they seem to be, "Dairy Fresh" is a potential application of vacuum puff drying. (Sinnamon, et al., 59)

A second method of foam drying, foam-mat drying, is similar to the vacuum puff method except that the foam is initially formed by agents and then dried under atmospheric pressure. Successful use depends upon producing a foam of suitable structure, i.e., one with many small, uniform, stable bubbles. The structure of the foam material permits high initial rates of water removal, as well as a relatively short dehydration cycle. Also the process requires only moderately low temperatures. This type of foam should retain its structure during drying. With the exceptions of egg whites, beef extract concentrate, and whole milk concentrate, it is often necessary to use film-forming additives such as solubilized soy protein, glycerol monostearate, and sucrous palmitate, to stabilize the foam. Initial work in this area was based on tomato paste, but now it includes milk products, coffee, pineapple lemonade, grape and orange juice, apricot puree, and a prune product containing egg albumen. (Holdsworth, 43) In addition, a recent study on the commercial feasibility of foam-mat dried instant orange juice gave promising results. (Berry et al., 9)

The usual need for foam stabilizing agents retards the commercialization of this process. These additives, especially glycerides of fatty acids, may impart an objectionable flavor to the

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product as well as altering the appearance of the reconstituted product. However, this problem is minimized by compacting.

Several attempts have been made to develop a continuous process of foam-mat drying for commercial use. Two basic methods were developed: a moving stack-tray system and a continuous belt system. One particular commercial unit utilizing the stock-tray system experienced serious mechanical problems, such as tray warpage, which impeded product removal by scraping. This, coupled with the inability of this particular system to attain an economical production capacity, led to its abandonment, although the complicated mechanical handling procedure of the stack-tray system can be eliminated with the continuous belt system.

Product recovery losses, which may be as high as 12 or 15 percent, are another potential problem of foam-mat drying. Although less extensive, the problem is present with solid belt dryers as well as tray dryers. However, the loss could be substantially minimized by controlling doctoring more closely or by eliminating continuous belt washing. (Hertzendorf and Moshy, 41)

Another method, Microflake dehydration, consists of drying a continuous sheet of foam 20 ml thick that has been placed on a continuous stainless steel belt. The latter is heated from below by steam and from above by a high velocity air stream. Drying time is reported to be about 1/10 that of the standard drying process. To produce a powder with 1.5 percent moisture content a temperature of approximately 170 degrees for one minute is required. One commercial unit is drying 30 million pounds of powder per year using the

Microflake technique. The quality of foam-dehydrated food has been on a par with that of vacuum-dried products, and for some items, even freeze-dried products. Although this method was first applied to orange juice, the company is also licensed to produce lemon, lime, grapefruit, pineapple, grape, banana, peach, and tomato crystals.

Foam-spray drying is different from the methods already described. Foam-spray drying is an extension of spray-drying and therefore requires only minor modifications of conventional spray-drying equipment, such as the addition of a gas supply, gas feed, and a mixing system to the dryer feed line. Foam-spray drying is used for product density control, for it decreases density by a factor of two. In conventional spray-drying, the powder is made of a hollow sphere surrounded by thick walls of dried material. However, the foam process produces particles having many internal spaces and relatively thin walls: therefore, the product reconstitutes more rapidly. (Hertzendorf and Moshy, 41; Holdsworth, 43)

The problems involved with storage stability of all foam dried products have not been completely solved. The porous structure of these products causes them, in the presence of oxygen and/or moisture, to have undesirable reactions which result in off flavors and the deterioration of the product. Therefore, special storage conditions are often necessary. For example, the USDA recommends storing vacuum-puff dried whole milk powder under vacuum conditions. Further, certain products must be packed in an essentially oxygen-free atmosphere which not only limits packaging possibilities, but also increases costs.

Low moistures in foam-dried products must be obtained either directly during the drying process, during a finish drying step, or during a conditioning period in a dry atmosphere. While some researchers, like Holdsworth (43), advocate silica gel and alumina as suitable in-package dessicants, others feel that these dessicants will probably not be acceptable for a consumer product. Product hygroscopicity is, therefore, a serious problem, and although compaction techniques are helpful in reducing hygroscopicity ultimately foam dried products may require suitable single portion packaging. (Hertzendorf and Moshy, 41)

Furthermore, if low-moisture products cannot be obtained by drying in all cases and if conditioned storage is required, the producer will need to maintain large product inventories. This will greatly increase storage and warehousing costs.

In conclusion, foam drying will probably not be a broadly applied dehydration technique, but rather one used for specific products. Once the food processing industry becomes convinced that these products have a market, foam drying will no doubt be adopted when relevant.

Drum Drying

A third method of dehydrating liquid foodstuffs is drum drying. For this process, a layer of wet material is deposited on the surface of one or more revolving steam-heated drums. The system has the capacity for a very high rate of heat transfer, but this also creates the problem of heat damaging the food. However, short residence times and reduced pressures can lesson the danger. Both a high rate of

production and a low moisture content can be achieved by operating at a high temperature. However, the drying rate is often limited by the temperature tolerance of the product.

At present drum drying is used very little. Milk is no longer dried this way; spray-dried milk is a more acceptable product. But some potato flakes are drum-dried, as are a large percentage of the readily rehydratable cereal products, such as baby cereals and "Instant" cereals. Laboratories both here and abroad have developed processes for applying the method to fruits and vegetables, but thus far commercial success has not occurred. One project studied the effect of some equipment modifications on the quality and stability of finished tomato puree. Because of a partial shroud and a low-humidity collection zone, the product could be inexpensively processed by drum drying. The product was removed from the drums with a high moisture content of from 5 to 7 percent, which yielded a superior product because there was no scorched flavor or color damage. Bin-finishing to a target moisture of from 2.5 to 3.5 percent required only three to six hours with forced air at 95 F and a 6 percent relative humidity. The product was stable for six months when air-packed. Since it can be dispensed from reclosable containers without caking, instant tomato sauce is available to the housewife or the manufacturer in any amount or consistency. The researchers estimate that for a commercial system starting with 20 percent solids, using a 3.5 by 10 feet drum dryer with 3.5 by 5 by 3 finishing bins, and producing 350 pounds per hour, the cost would be 4.5¢ per pound of dry tomato puree. (Lazar and Miers, 49)

Frozen Foods: The Fastest Growing World in
The Universe of Food

"The fastest growing world in the entire universe of foods is the frozen food world.... Frozen foods will be the number one gainer in the food industry in the seventies." (Karnes, 45)

"Everyone knows that prepared frozen foods are the wave of the future and that the time may come when stores are filled with heat-and-eat specialities instead of raw commodities" (Katx, 46)

"Many operators in all segments of the food service industry--both commercial and institutional--report using 25 to 80 percent frozen foods in their menus. These operators also expect to be increasing their use of frozen foods as much as 40 percent by 1974." (Angione, 6)

These three quotes are examples of the general mood characterizing the frozen food industry. Without a doubt the industry is growing rapidly. The total sales in 1972 were up a phenomenal 13.6 percent--the biggest jump in ten years--with strong gains being chalked up for everything but frozen fruit (see Tables 1 and 2). Production also achieved a near-record gain of 6.7 percent, including a very remarkable increase in the packing of frozen foods for the institutional market.

TABLE 1

Value Of All Frozen Foods* From 1942
Through 1972

1942	\$ 162,000,000	1957	2,362,000,000
1943	178,000,000	1958	2,320,000,000
1944	197,000,000	1959	2,749,000,000
1945	257,000,000	1960	3,037,000,000
1946	324,000,000	1961	3,638,000,000
1947	245,000,000	1962	3,960,000,000
1948	292,000,000	1963	4,381,000,000
1949	375,000,000	1964	5,246,000,000
1950	500,000,000	1965	5,765,000,000
1951	700,000,000	1968	7,033,236,000
1952	875,000,000	1969	7,641,114,000
1953	1,200,000,000	1970	7,931,000,000
1954	1,450,000,000	1971	8,128,000,000
1955	1,700,000,000		
1956	2,106,000,000	1972	9,230,000,000

* Includes all sales of frozen fruits, vegetables, concentrates, poultry meats, seafoods, and prepared foods at conservative retail prices or at average prices paid by institutions and reproducers. As a generality, it can be said that retail sales make up 65% of the total figure, but this percentage fluctuates so greatly from product group to product group that it cannot be used as a rule of thumb. Of sales made through retail stores, frozen food chains with two or more stores account for 70% of the business.

From: Quick Frozen Foods (December, 1973) 36(5): pg. 46.

In the same year, institutional foods led the way in both sales and production increases with a 9.2-percent rise in the volume of frozen foods bought by the food service sector. Private restaurants, chain operators, and hospital directors now accept red meat that has been quick frozen, as well as frozen turkey products, for example. But despite the fact that the food service field, especially in the area of airlines and contract feeders is switching to frozen convenience foods in increasing numbers, retail sales still account for most prepared frozen food production (Katz, 46)

Fish and seafood entrees are the most popular frozen foods because they are more convenient and available than fresh fish or fish that is preserved by other methods. (Foda et al., 28) Also, both retail and institutional consumption of frozen vegetables (notably potatoes, green beans, lima beans, and green peas) moved ahead vigorously in 1972, although the increase was more marked on the institutional side. And although the overall sales of frozen fruits declined in the same year, frozen apple sales to the institutional sector were up, (Katz, 46) and food service directors in all sectors of institutional feeding say they are now beginning to use more pre-prepared frozen fruits because they save time. (Foda et al., 28) The biggest sellers in the food service industry now are frozen hamburger patties, breaded fish portions, potatoes (especially french fries), onion rings, cream and fruit pies, juices, and poultry. These items will probably remain as important throughout the seventies. (Havighorst, 35)

There are several reasons why food service operators are using frozen foods. First, many frozen food processors are making exciting

TABLE 2

1972 Frozen Food Poundage and Dollar Values

	poundage (lb)			dollar value (\$)		
	<u>Retail</u>	<u>Institutional</u>	<u>Total</u>	<u>Retail</u>	<u>Institutional</u>	<u>Total</u>
Prepared Foods	3.398B	683M	4.081B	\$2.290B	\$402M	\$2.692B
Seafoods	502M	832.7M	1.134B	\$626.5M	\$1.151B	\$1.77B
Poultry	1.712B	606M	2.318B	\$894M	\$320M	\$1.214B
Vegetables	2.119B	2.925B	5.044B	\$706M	\$786M	\$1.492B
Meats	372M	633M	1.005B	\$380M	\$575M	\$955M
Juices & Drink	1.619B	407M	2.098B	\$710M	\$132M	\$842M
Fruits	70M	627M	697M	\$41M	\$217M	\$258M
Total	9.864B	6.714B	16.578B	\$5.617B	\$3.583B	\$9.230B

Adapted from: Quick Frozen Foods 36(5): 46-47 December, 1973

new convenience products that are tailored to the needs of the food service operators (Foda et al., 28) If purchased, stored, and prepared properly, these products are usually of high quality, an important factor in their popularity. (Havighorst, 35) Second, frozen foods reduce labor costs and save on equipment purchases--partly because they dictate exact portion quality and often quantity. Third, seasonal products are not often "out-of-stock." Finally, since frozen foods usually require less preparation, faster service and faster inventory turnover are possible.

Slow vs. Rapid Freezing

Still, probably the most important factor determining sales is the quality of the product. In order to maintain texture and organoleptic properties of a frozen product, a continuous freezing process is necessary. However, freezing will always induce major alterations in foods such as death of tissue with loss of consistency, drip of cellular fluids and altered organoleptic properties. The best method, then, involves limiting the size of the ice crystal, preventing the development of long ice needles, and reducing the disruption of cells to a minimum. This will, generally, be done by fast freezing the food to low temperatures in order to stop biochemical and enzymatic activities. Rapid freezing is recommended for fish and meat, for example, because large ice crystals may have disrupting effects on the fine tissue and because strong hypertonic fluids which develop in the course of freezing could destroy the physical-chemical equilibria if allowed to stand for too long. Also when specific aromatic or nutritional properties need to be maintained, as in fruit juices, milk, tea and coffee extracts,

the main problem is to avoid, during processing, denaturation of the substances responsible for taste and aroma since this might result in unbalancing the flavor of the products when they are brought back to utilization temperatures. All these examples illustrate that usually a faster freezing rate produces a better quality product (Rey, 57)

In contrast, studying the effect of freezing rate on chicken meat quality, researchers found that slow freezing caused a larger loss in thawing drip of cellular fluids, a larger loss of nitrogenous constituents and nucleic acid derivatives, and a decreased holding capacity in the meat. On the other hand, fast freezing, inhibits proteolysis, preserves better the integrity of muscle proteins and induces no significant changes in the color, odor, and taste of uncooked breast or leg meat. Although this case cites a spectacular improvement in quality due to an increased freezing rate, not all products benefit from rapid freezing. (Rey, 57)

Freezing Methods

At the present time, there are a number of different methods of freezing available to the frozen food processor. Air blast freezing is the most versatile of the methods and has the longest history of commercial application. This method freezes the product in a storage room by using fans to circulate cold air. The obvious disadvantage of this method is that it takes a long time to freeze the product. Small packages freeze overnight, cased goods and barrels take many days.

The air blast tunnel freezer is an improvement over the first system. Using very fast air movement and air temperatures of from -35 to -40 F, it freezes the product much faster. This method is used

primarily for packaged fruits, vegetables, bakery goods, meats, poultry, and prepared dishes. Packages are usually put on trays, which in turn are put onto dollies or trucks. With properly spaced shelves and packages, freezing time can be decreased to a few hours for many items. Some unpackaged items are also frozen this way.

A third method, conveyor tunnel freezing, is a variation on the second system. This system uses conveyors which move food on an endless belt or chain through a freezing zone of rapidly moving air at 35 F or CO₂ gas at approximately -100 F. Meat patties, chicken parts, bakery goods, and other individually proportioned foods, packaged or unpackaged, are frozen in such units. Freezing takes only a matter of minutes, and automated loading and unloading can be found in some of these systems.

Bulk freezing on conveyors is another method. In this system, such piece items as peas, cut corn, beans, etc., are piled several inches deep on a belt and passed through the freezing zone where -35 F air blows. The system permits storage of frozen food in bulk. Packaging is done later during a slack season or upon order. Freezing by this method is faster than freezing in packages, but not as fast as IQF (Individual Quick Freezing). Therefore, evaporative losses may still be undesirably high.

Fluidized beds are used to achieve a rapid IQF. In this system, air flows upward through the belt at a sufficient force to fluidize or practically float the food pieces. Thus each piece is continually moved and turned and all surfaces are exposed to the freezing air stream. This rapid freezing improves textural quality, and the shorter exposure to the freezing medium lessens evaporation. An added advantage

of IQF is thawing. For example, instead of a restaurant chef or a baker thawing an entire 30-pound can of food, he can simply pour out the amount he needs. The IQF product will thaw quicker because only the individual items, rather than all the ice holding together a solid block, has to thaw.

IQF for liquid products is a very new concept. Such liquids as juices, purees, soups, pulps, and dairy products, may be frozen in a unit similar to an automatic ice cube maker to form pillow-shaped products. The advantages of this method over liquids previously frozen in a solid block include convenience in thawing and a cheaper package (perhaps a plastic film in a carton instead of the conventional metal can).

With plate freezers, heat transfer is by conduction (which in theory is more efficient than the convection methods already described). However, packaging the product partially offsets the advantage. For products that are packaged before freezing, such as asparagus, cauliflower, spinach, broccoli, and other irregularly shaped foods, plate freezing may offer the fastest practical freezing rate. The labor cost of plate freezing is potentially high because usually hand labor is required for loading and unloading, although modern plate freezers are highly automated and labor requirements are minimal. Such automation, however, makes a plate freezer even more costly.

The contact freezer is essentially a plate freezer of unpackaged goods. This system uses either a belt or a drum. One version uses a double-walled drum with the refrigerant circulating between the walls. The product rides on the outside of the drum, maintaining refrigerant-

to-metal-to-product contact. Evaporation is virtually eliminated, maintenance is minimal, and losses due to the product's sticking to the drum or breaking when it is removed are claimed to be nil. However, this method is limited to uniform, flat or round materials that can be easily spread on a belt. Manufacturers have claimed that a one-inch thick steak can be frozen in 20 minutes and small shrimp in four minutes (Rasmussen and Olsen, 56)

The final freezing methods to be discussed are immersion and spray freezing. In both cases a liquid, rather than air, is the refrigerant. The advantages of liquids over air are twofold. First, a liquid is a far better conductor of heat than air. Therefore, a more rapid rate of freezing can be achieved, even though the liquid may be at a higher temperature than that normally used in air blast. Second, lower temperatures are available when cryogenic liquids, which will be discussed later, are used. As their names indicate, immersion freezers operate by immersing the unfrozen product in the freezant, and spray freezers operate by spraying the freezant onto the items. Alcohols, such as propylene glycol and ethylene glycol, and brine are the common noncryogenic liquids that have been used commercially for many years. These liquids have boiling points in the range of 0 F to -20 or -30 F, and they can be used effectively to freeze such large items as turkeys at a fairly rapid rate. Protective wrapping of the product is essential. The usual wrapper is a shrink-wrap plastic that forms a good barrier between the product and liquid and also permits rapid heat transfer. A new refrigerant, dichlorodifluoromethane (R12), was approved by the FDA on August 13, 1967, and has found commercial application. Although its boiling point is within the noncryogenic range, it freezes items

at rates comparable with the cryogenics and will therefore be included in the discussion of cryogenics.

Cryogenic Freezing

In 1966, the United States had 35 cryogenic freezing operations. By 1969, the number had grown to over 100. Today, still more exist. To understand why the number of cryogenic installations has grown, it is necessary to examine the cryogenics along with their advantages and limitations. Cryogenic liquids, those having boiling points below -100 F, include liquid nitrogen (LN), liquid air, liquid carbon dioxide (LCO_2), and solid carbon dioxide. As previously mentioned, dichlorodifluoromethane (R12), although not a true cryogen, is usually included with the cryogenics. Cryogenic methods have been used mainly for freezing beef, sea food, and poultry, and to a lesser extent, for freezing bakery products, pizzas, onion rings, and commissary items.

Carbon dioxide. Carbon dioxide is a by-product of many chemical processes and is therefore readily available at a low cost, offering wide possibilities as a freezing agent. Carbon dioxide is most commonly used as dry ice or carbon dioxide snow, which sublimates spontaneously at -78.8 F. However the solid-to-solid heat-transfer is not as efficient as a liquid-solid system. This is why other systems, in which CO_2 is directed from nozzles onto the food, have been developed. In these systems a very fine snow mixes with the material. But here again, the sublimation of particles prevents intimate contact with the product, and can delay freezing. Furthermore, research must be conducted to be sure that a chemical reaction between CO_2 and the product will not harm the product. On the other hand, carbon dioxide snow is still used